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Abstract

The third full annual inventory of Iowa's forests (2009-2013) indicates that just under 3 million acres of forest land exists in the State, 81 percent of which is in family forest ownership. Almost all of Iowa's forest land is timberland (96 percent), with an average volume of more than 1,000 cubic feet of growing stock per acre on timberland and more than 1,500 cubic feet of all live volume (for trees at least 5 inches diameter at breast height) per acre on timberland. American elm and eastern hophornbeam are the most numerous tree species, but bur oak and silver maple predominate in terms of live-tree volume. Iowa's forest land is composed of 70 percent sawtimber, 17 percent poletimber, and 13 percent sapling/seedling or nonstocked size classes. Average annual net growth of growing-stock trees on Iowa's timberland decreased during the past decade to the current estimate of 71 million cubic feet. This report includes additional information on forest attributes, land-use change, carbon, timber products, wildlife habitat, forest health, and future projections. The following information is available online at <http://dx.doi.org/10.2737/NRS-RB-102>: 1) descriptive information on methods, statistics, and quality assurance of data collection, 2) a glossary of terms, 3) tables that summarize quality assurance, 4) a core set of tabular estimates for a variety of forest resources, and 5) a Microsoft® Access database that represents an archive of data used in this report, with tools that allow users to produce customized estimates.

Acknowledgments

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Cover: Fall colors on a ridge trail in Waubonsie State Park, Fremont County, Iowa. Photo by Lindsey Barney, Iowa Department of Natural Resources, used with permission.

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Iowa Forests, 2013

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Foreword

This report highlights the current status, ongoing trends, and future direction of Iowa's forests. The Iowa forest inventory is conducted as a cooperative program between the Iowa Department of Natural Resources, Forestry Bureau, and the Forest Inventory and Analysis program of the U.S. Department of Agriculture, Forest Service. Periodic inventories of Iowa's forests were conducted in 1954, 1974, and 1990. Starting in 1999, annual inventories were conducted wherein a portion of field plots were inventoried each year and after 5 years a full inventory was completed. Previous annual inventories were conducted for the periods 1999-2003 and 2004-2008. This inventory covers the period 2009-2013. With complete remeasurement of annual inventory plots, we produced better estimates of growth, mortality, and removals and detailed land-use change.

Results from this inventory show Iowa's forests continue to grow more wood than is being harvested, providing an important and essential element to our State's economy, the wood industry, and individual woodland owners. Iowa's forests also continue to provide fine-quality hardwood products, habitat for wildlife, clean water and air, protection of soil from erosion, and additional ecosystem services.

Although Iowa's woodlands continue to gain volume as trees become larger, there are some areas of serious concern. Acres of Iowa forest land have shrunk to 2.97 million acres with a net loss of 97,000 acres since the last reporting period. This is the first recorded net loss of forest acres in Iowa since the 1974 inventory. Other areas of concern include the continuing decrease in the average size of forest tracts, the increasing presence of nonnative exotic invasive woodland plant species, the increasing impact of insect and disease pests such as emerald ash borer and bur oak blight, browse impacts from white-tailed deer, and the loss of young oak and early successional forest stands from the Iowa landscape.

These and other issues require ongoing monitoring to inform future management decisions. I invite you to read and interpret the latest results of Iowa's forest inventory, to become more interested in our forest resources, and to participate in discussions about the future of forests and forestry in Iowa.

Paul J. Tauke
State Forester
Iowa Department of Natural Resources

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Black oak grandeur at Waubonsie State Park, Fremont County, Iowa. Photo by Lindsey Barney, Iowa Department of Natural Resources, used with permission.

Highlights

On the Plus Side

- Iowa's forests contain more than 1 billion trees of at least 60 species statewide.
- Iowa's black walnut resource ranks first in number of trees per acre on timberland when compared with estimates for the surrounding states of Minnesota, Wisconsin, Illinois, Indiana, Missouri, Kansas, and South Dakota during 2008-2012 (the most recent year available for all states).
- Timberland makes up the vast majority (96 percent) of forest land.
- Total growing-stock volume on timberland has more than doubled since the 1954 and 1974 inventories, to a current statewide estimate of more than 3 billion cubic feet.
- The volume of sawtimber on timberland exceeds 11 billion board feet (International ¼-inch rule).
- Average annual net growth is more than three times the average annual harvest removals of growing-stock trees on timberland.
- Iowa's most important tree species are generally in good health, with low incidence of poor crowns and little dieback for most species.
- Number of standing dead trees (snags) per acre increased slightly between 2008 and 2013, to the current density of 12.1 per acre of forest land, providing important habitat features for wildlife.
- Late successional forest of older age classes and larger diameter classes continues to increase in area.
- An estimated 95,000 family forest owners control 81 percent of the forest land in Iowa; the 5 most common reasons for owning family forest land are to protect wildlife habitat, to enjoy scenery, to protect nature, to protect water resources, and because it is part of their home.
- Downed dead wood biomass is dominated by coarse woody debris, providing wildlife habitat and carbon sequestration.
- In 2013, the wood products and related industries in Iowa employed almost 12,000 people, with an average annual payroll of \$648 million.

- The number of employees working in the forest products industry increased from the previous year for the first time since 2005.
- More than 99 percent of mill residues were used for products.
- The quantity of live biomass on timberland has increased at a steady rate since 1990; total biomass now exceeds 100 million oven-dry tons.
- Overall forest carbon per acre increased by 4 percent relative to 5 years ago, and live tree carbon values increased by 9 percent.
- Nonforest trees in Iowa contribute an important resource beyond trees inventoried on forest land.

Areas of Concern

- After increasing for more than three decades, Iowa's forest land area plateaued at 3 million acres during the last inventory, and has since decreased.
- Although only 1 percent of Iowa's land area changed land use between 2008 and 2013, diversions (losses) from forest to nonforest exceeded reversions (gains) from nonforest to new forest land, leading to a 2 percent net loss of forest area.
- During the past decade, average annual growth has declined and average annual mortality has increased.
- The fraction of trees with low quality grades decreased between 1990 and 2003, but has since been increasing gradually.
- For other eastern soft hardwoods species group (mostly American elm), the total statewide average annual mortality is nearly 19 million cubic feet, a rate of 4 percent of volume per year.
- Forest in the 0- to 20-year-old age class has decreased by nearly half since 2008, reducing habitat abundance for early successional species.
- The forest land base of Iowa is highly fragmented due to agriculture and development; a small minority of forest is "core" (having the highest spatial integrity) and a majority of forest is in unconnected fragments.
- Almost 95 percent of plots contain 1 or more of the 15 species of nonnative invasive plants recorded on Iowa plots inventoried by the U.S. Forest Service, Forest Inventory and Analysis (FIA) program. Multiflora rose is the most prevalent, occurring on more than 60 percent of plots.

- Only 11 percent of family forest ownerships have a written management plan; only 17 percent have received forest management advice.
- The last pulp mill in the State closed in 2005. Without this market, a large volume of small dimension wood material above the saw log top is underutilized.
- Emerald ash borer, an exotic wood-boring beetle that has become established in Iowa, threatens all North American ash tree species in both forests and urban environments; ash mortality was fairly stable from 1990 to 2008, but doubled between 2008 and 2013.
- Although most of the browse impact was found to be at a medium level, about one-quarter of the samples had high or very high browsing impact.

Issues to Watch

- Rate of gross forest loss remained relatively stable between 2008 and 2013; the difference in net change between the two inventory periods can be attributed primarily to a drop in the amount of nonforest land that reverted to forest. If gross gains in forest no longer offset losses, net area of forest land will decrease in future years.
- Increases in the human population and number of housing units are resulting in an increasing percentage of forest land in the wildland-urban interface.
- Future pressures to harvest Iowa's forests for energy may compete with traditional forest products industries, and increased harvest utilization rates could diminish forest sustainability (via decreases in harvest residues) and habitat quality.
- Most tree species groups continued their slightly increasing trend in total statewide live-tree volume during the past 10 years, with the exceptions of cottonwood and aspen, soft maple, and other eastern softwoods species groups.
- Gypsy moth is a nonnative insect pest that recently entered Iowa; more than half of the live-tree volume in Iowa is in tree species preferred by gypsy moth. Bur oak blight also is expected to cause significant damage to Iowa's forests.
- Future management of forests to maximize carbon sequestration could complicate timber management practices due to fluctuating carbon credit markets and consideration of all carbon pools in forests (e.g., soil organic carbon, dead wood, and belowground stocks).

- The average parcel size of privately owned forest land in Iowa continues to decrease with indications that these holdings will be changing owners; family legacy—keeping land intact for future generations—is an important concern.
- Small, localized, industrial fuelwood or wood pellet manufacturers could increase future utilization of the forest resource.
- Oak/hickory forest-type group accounts for about two-thirds of Iowa's forest and is critical for timber and for providing acorns for wildlife; young stands now account for less than 3 percent of the oak/hickory forest-type group, adding to concern about future abundance of this important species group.
- Volume of high quality sawtimber is increasing for some species groups and decreasing for others.
- With the improving economy and increasing demand for wood products, the forest products mills that were able to withstand the recession are beginning to increase their production, resulting in a potential increase in the number of employees in the forest products industry.
- Projections of future forest conditions through the year 2060 suggest that elm/ash/cottonwood forest-type group will decrease in forest area and oak/hickory forest-type group will increase; these opposite trends are partially offsetting when mortality to individual ash and elm trees results in reclassification of forest-type groups.
- Future tree mortality resulting from emerald ash borer is projected to result in the loss of 16 million ash trees at least 5 inches in diameter at breast height from Iowa forest land by 2060.
- Changing climate patterns are projected to affect some bird species negatively and others positively.

Background



Bur oak in Iowa. Photo by Iowa Department of Natural Resources, used with permission.

An Overview of Forest Inventory

What is a tree?

Trees are perennial woody plants with central stems and distinct crowns. In general, the Forest Inventory and Analysis (FIA) program defines a tree as any perennial woody plant species that can attain a height of 15 feet at maturity. A complete list of the tree species measured in Iowa during this inventory is included in the appendix. An electronic record of every tree measured in this inventory, as well as a glossary of additional terms, is available online at <http://dx.doi.org/10.2737/NRS-RB-102>.

What is a forest?

The FIA program defines forest land as land that has at least 10 percent canopy cover of live tally tree species of any size or has had at least 10 percent canopy cover of live tally species in the past, based on the presence of stumps, snags, or other evidence, and not currently developed for nonforest use(s) that prevent normal tree regeneration and succession. The treed area must be at least 1 acre in size and at least 120 feet wide to qualify as forest land. Trees in narrow windbreaks, urban boulevards, orchards, and other “nonforest” situations are very valuable too, but they are not fully addressed in this report (see Nonforest Trees section on p. 61 for more information.)

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

FIA defines three subcategories of forest land: reserved forest, other forest land, and timberland. Reserved forest is land that has been withdrawn from timber utilization through legislation or administrative regulation. Other forest land typically has poor soils where the forest is incapable of producing 20 cubic feet per acre per year at the culmination of mean annual increment (growth). Timberland is forest land that is not reserved and meets minimum productivity requirements.

During some periodic inventories conducted before 1999, only trees on timberland plots were measured. We are therefore unable to report estimates for some attributes (e.g., volume) on nontimberland for those older inventories. Beginning with the implementation of FIA's annual inventory system during 1999-2003, we were able to report forest attributes on all forest land—not just timberland. With the remeasurement of the same annual inventory plots during 2004-2008, and again during 2009-2013, we can now report growth, removals, and mortality on all forest land, whereas for prior inventories we could report growth, removals, and mortality only on timberland.

How do we estimate forest land area and number of trees?

Forest inventory plots have been established throughout Iowa, with 1 plot for approximately every 6,000 acres, including 5,426 nonforest plots and 641 forest plots. Only those plots located on forest land are measured “in the field.” Together these plots make up a statistical sample of observations used for estimating various forest attributes. During the 2009-2013 inventory, 13,259 trees that are at least 1 inch in diameter at breast height (d.b.h., 4.5 feet above the ground) were measured on forest plots in Iowa. Unless indicated otherwise, sampling errors reported in text and figures represent 1 standard error (SE). For information on sampling errors, see the Statistics, Methods, and Quality Assurance section available at <http://dx.doi.org/10.2737/NRS-RB-102>.

How do we estimate a tree's volume?

Forest inventories typically express volume in cubic feet (or cubic meters), but many Iowans are more familiar with cords (a stack of wood 8 feet long, 4 feet wide, and 4 feet high). A cord of wood, which is a typical unit for firewood, contains about 79 cubic feet of solid wood and 49 cubic feet of bark and air. Volume can be determined precisely by immersing a tree in a pool of water and measuring the amount of water displaced. A less precise, but much cheaper and easier, method has been used in forest inventories, whereby several hundred trees were cut, and detailed diameter measurements were taken along their lengths to accurately determine their volumes (Hahn 1984). Statistical tools were used to model these data by tree species group. Using these models, we can estimate tree volume based on species, diameter, and tree site index. This method was also used to calculate sawtimber volumes. FIA reports sawtimber volumes in International ¼-inch board foot scale as well as Doyle rule. To convert to the Scribner board foot scale, see Smith (1991).

How much does a tree weigh?

Building on previous work, the U.S. Forest Service's Forest Products Laboratory and others developed specific gravity estimates for many tree species (Miles and Smith 2009). These specific gravities are applied to estimates of tree volume to derive estimates of merchantable tree biomass (the weight of the tree's merchantable bole). All live-tree biomass is estimated by including biomass estimates for the stump, top and limbs, and bark. We do not currently report the live biomass in roots or foliage. Forest inventory can report biomass as either green weight or oven-dry weight. Green weight is the weight of a freshly cut tree. Oven-dry weight is the weight of a tree with no moisture content. On average 1 ton of oven-dry biomass is equal to 1.9 tons (2,000 pounds/ton) of green biomass.

How do we estimate all the forest carbon pools?

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

How do we compare estimates from different inventories?

Estimates from new inventories are often compared with earlier inventories to determine trends in forest resources. References to 1954, 1974, and 1990 periodic inventories each refer to that single year of Iowa inventory, but references to 2003, 2008, and 2013 annual inventories refer to the 5-year periods ending in those years, i.e., 1999-2003, 2004-2008, and 2009-2013, respectively. Comparisons are valid between 2003, 2008, and 2013 inventories, all three of which are based on FIA's "annual inventory" system. Comparisons with older periodic inventories, however, are problematic because procedures for assigning stand characteristics such as forest type and stand size have changed as a result of FIA's ongoing efforts to improve the efficiency, reliability, and national consistency of the inventory. Several changes in procedures and definitions have occurred since the 1990 Iowa inventory. Although these changes will have minimal impact on statewide estimates of forest area, timber volume, and tree biomass, they may have significant impacts on plot classification variables such as forest type and stand-size class (tree diameter class). Some of these changes make it inappropriate to directly compare the 2013, 2008, and 2003 annual inventory tables with those published for the 1954, 1974, and 1990 periodic inventories. Note that estimates of timberland and forest land area reported in the 1954 Iowa report (Thornton and Morgan 1959) were subsequently adjusted in the 1974 Iowa report (Spencer and Jakes 1980) to account for changes in definitions. Adjusted estimates for the 1954 inventory are cited within this report. Features for which no new data are available (e.g., soils, ozone, lichens) are not included in this report.

Reserved status—improved implementation

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

In an effort to increase consistency among states and across inventory years, a refined set of procedures determining reserved status has been implemented with version 6.0 of the FIA field manual, which took effect with the 2013 inventory year (which began in October 2012). Furthermore, all previously collected annual inventory data (1999 to present) have been updated by using the new standardized interpretation.

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

A word of caution on timberland suitability and availability

The FIA program does not attempt to identify which lands are actually suitable or available for timber harvesting. Land classified by FIA as “timberland” is not necessarily suitable or available for timber production, but merely has the potential for such production. Actual suitability and availability are subject to changing laws, economic and market constraints, physical conditions, adjacency to human populations, ownership objectives, and other factors.

How do we produce maps?

Maps produced by FIA are for graphic display to meet general reporting requirements. A geographic information system (GIS) and various geospatial datasets were used to produce the maps in this report. Unless indicated otherwise, forest resource data are from FIA, and base map layers, such as state and county boundaries, were obtained from the GIS section of the Iowa Geological and Water Survey (Iowa Department of Natural Resources, n.d.a). Depicted FIA plot locations are approximate. Sources and intended uses of FIA data are available at www.fia.fs.fed.us/tools-data. Sources of other geospatial datasets are cited within individual figures. Iowa maps are portrayed in Universal Transverse Mercator (UTM) projection, Zone 15, North American Datum (NAD) of 1983.

Forest Features



Black oak in Militia Hollow, Waubonsie State Park, Fremont County, Iowa. Photo by Lindsey Barney, Iowa Department of Natural Resources, used with permission.

Forest Area

Background

Characteristics of geology and climate affect forest distribution, composition, and structure. These characteristics are used to delineate ecological regions, which are shown in Figure 1 (Griffith et al. 2008). A mixture of land uses occurs in the Central Irregular Plains in the south-central portion of the State, with wider forested strips occurring along streams. One-fifth of the Interior River Lowland, in southeastern Iowa, is in forest, including bottomland deciduous forest, swamp forest, and mixed oak and oak-hickory forest. Flat-bottomed terraced valleys, forested valley slopes, and dissected glacial till plains characterize this ecoregion. In northeastern Iowa, the Paleozoic Plateau, also known as the Driftless Area, consists of hilly uplands and deeply dissected valleys, containing a significant portion of Iowa’s forests and most of its trout streams. Three-fourths of the Western Corn Belt Plains are used for cropland agriculture, with much of the remainder used for livestock forage. This region is characterized as nearly level to gently rolling, with warm, moist soils that support the most productive areas of corn and soybeans in the world. Spatial distribution and trends in forest area may indicate future forest resource trends resulting from changing land use or forest health conditions. Management and decisionmaking depend upon forest monitoring for providing essential information on forest trends.

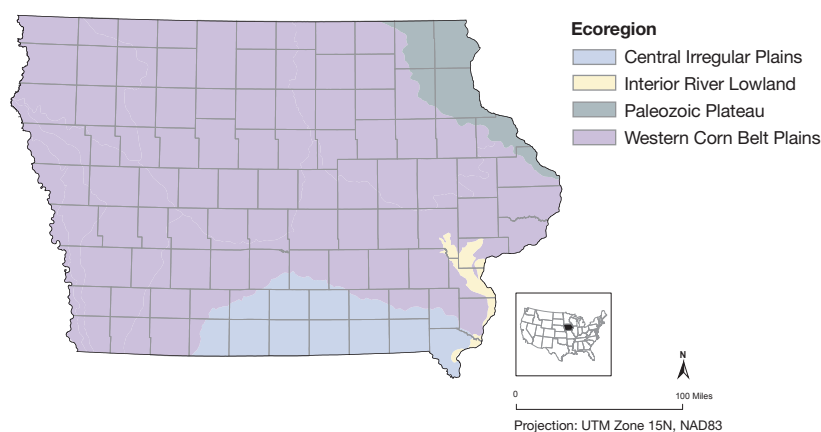


Figure 1.—Level III Ecoregions of Iowa. Data source for ecoregions: Iowa Department of Natural Resources (n.d.b); for inset: ESRI Data & Maps.

What we found

Iowa forest land area is most concentrated in the northeastern and southern counties, which are located in three of the four geographic inventory units (Fig. 2). After declining from 2.3 million acres in 1954 to a low of 1.6 million acres in the 1970s, area of forest land increased at a steady rate, reaching a peak of more than 3 million acres during the past several years, then declining slightly to the current estimate of 2.97 million acres (Fig. 3). Almost all (96 percent) of Iowa’s forest land is timberland; 3 percent is reserved forest land, and 1 percent is other forest land.

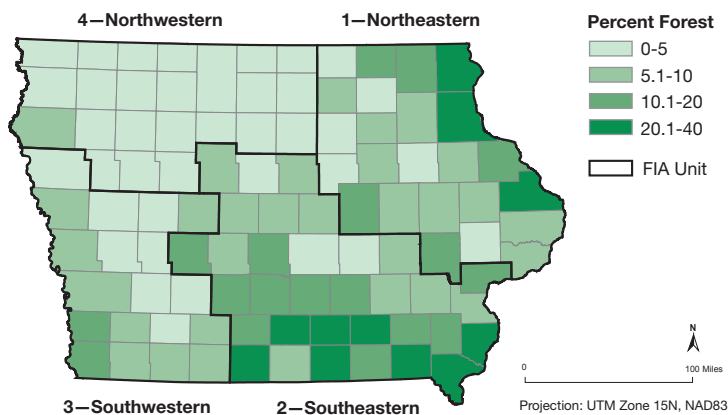


Figure 2.—County-level forest land area as a percentage of total land area, and location of the four FIA units in Iowa, 2013.

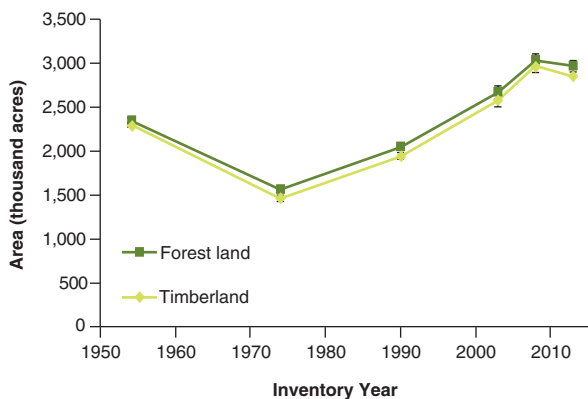


Figure 3.—Area of forest land and timberland by inventory year, and associated sampling error, Iowa, 1954 to 2013. Error bars represent a 68 percent confidence interval around each estimate.

What this means

At the state level, Iowa's forest land and timberland areas have been gradually increasing since the 1970s, peaking a few years ago. Because nearly all forest land in Iowa is timberland, subsequent sections of this report that refer to estimates on timberland most likely are representative of all forest land within the State. Relatively large sampling errors are associated with the FIA inventory estimates at sub-state scales, so care should be given when monitoring changes in the area of forest land or timberland at these scales.

Land-Use Change

Background

Although forests cover only 8 percent of the land area in Iowa, they are a critical resource and offer a wide range of benefits. Tree and vegetation cover limit the loss of Iowa's fertile soils by protecting against erosion. Riparian forests serve as stream buffers, protecting and clarifying the State's water resources. Forests provide habitat for forest-dwelling species and provide economic and other benefits for humans. Although the total area of forest land in Iowa remained fairly stable between 2008 and 2013, some areas of the State experienced forest loss, whereas other areas saw increases in forest land. To better understand Iowa's forest land dynamics, it is important to explore the underlying land-use changes occurring in the State.

FIA characterizes land area by using several broad land use categories: forest, rangeland, agriculture, water, developed, and other land. The conversion of forest land to other uses is referred to as gross forest loss (or diversion), and the conversion of nonforest land to forest is known as gross forest gain (or reversion). The magnitude of the difference between gross loss and gross gain is defined as net forest change. By comparing the land uses on current inventory plots with the land uses recorded for the same plots during the previous inventory, we can characterize forest land-use change dynamics. Understanding land-use change dynamics is essential for monitoring the sustainability of Iowa's forest resources and helps land managers make informed policy decisions.

What we found

The land area in Iowa is dominated by cropland and pasture. These agricultural land uses, along with urban and other nonforest land uses, cover 92 percent of the State's surface area (Fig. 4). Commercial and residential development is limited and is primarily concentrated in the central part of the State surrounding Des Moines and Cedar Rapids. Between 2008 and 2013 most of the FIA plots in Iowa either remained forested (8 percent) or stayed in a nonforest land use (91 percent) (Fig. 4).

On the 1 percent of FIA plots where land use changed between inventories, the amount of land that was diverted from forest to nonforest exceeded acreage of nonforest that reverted to new forest land, leading to a net loss of forest land of 2 percent. According to FIA remeasurement data, Iowa lost 192,000 acres (6 percent) of forest land from 2008 to 2013, which was only partially offset by a gain of nearly 95,000 acres (3 percent) during the same time period (Fig. 5). Seventy-one percent of the gross forest loss was due to diversion to agricultural land uses including cropland (31 percent), pasture (26 percent), and agricultural land grouped with idle farmland (14 percent). The other 29 percent of forest loss was forest land converted to water or marsh (15 percent), rangeland (6 percent), developed land (4 percent), and rights-of-way (4 percent) (Fig. 6). Sixty percent of forest gain in Iowa was from agricultural land, primarily cropland (40 percent) converting to forest. Other land use sources for new forest land included water and marsh (18 percent) and developed land (15 percent) (Fig. 6).

FIA data can be used to characterize the forest land that has been lost and gained to see if it differs from the characteristics of forest land in all of Iowa, the large majority of which is persisting. Iowa's forests are dominated by stands in the large diameter size class (69 percent). However, new forest land that has been gained in the State is classified primarily as small diameter stands (53 percent). Similarly, the forest land that has been lost has a greater proportion of small diameter stands (41 percent) than in Iowa as a whole (12 percent). Figure 7 shows the distribution of remeasured plots across Iowa, highlighting plots where forest land has been lost and gained. Forest change plots are concentrated in the southern and eastern parts of Iowa, where forest cover is most prevalent.

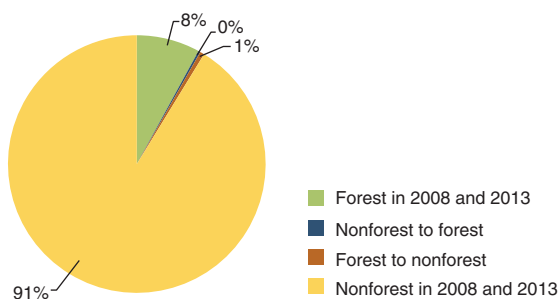


Figure 4.—Proportion of land with unchanged land use, gain in forest land from nonforest land, and loss of forest land to nonforest use, Iowa, 2008-2013.

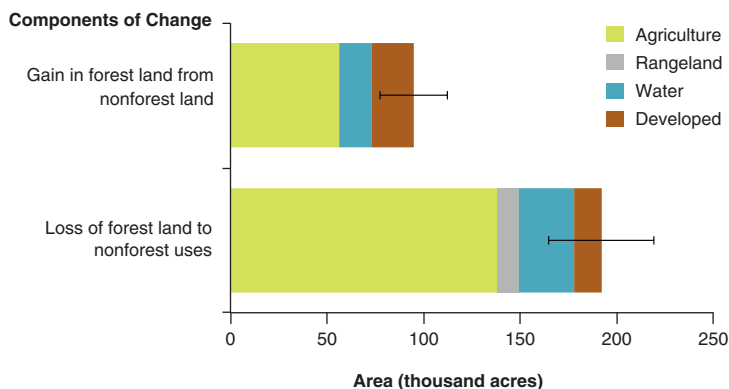


Figure 5.—Change in forest land by land use category, and associated sampling error, Iowa, 2008-2013.

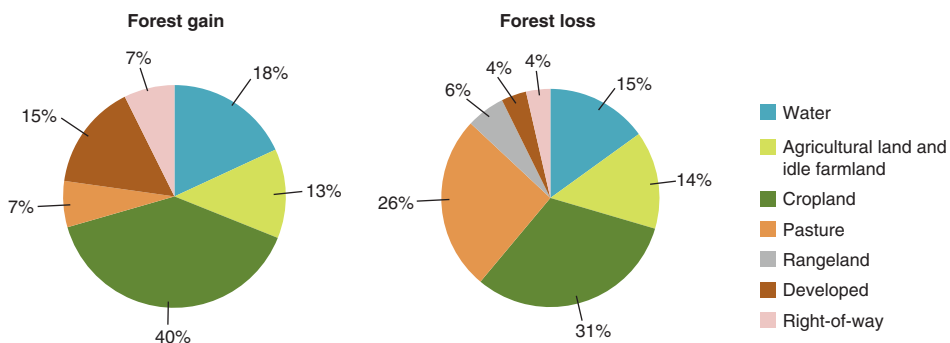


Figure 6.—Forest gain by previous land use and forest loss by current land use, Iowa, 2008-2013.

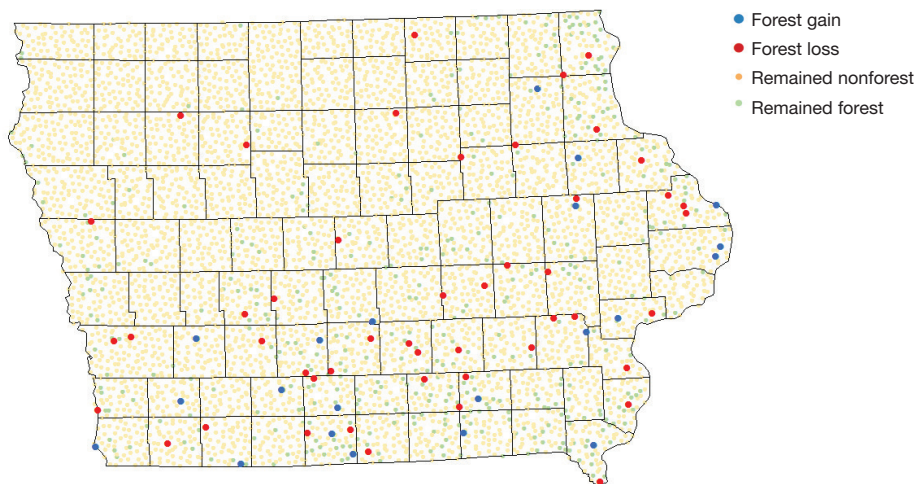


Figure 7.—Distribution of remeasurement inventory plots showing forest gains and losses, Iowa, 2008-2013. (Depicted plot locations are approximate.)

What this means

Agriculture is the dominant land use in Iowa and gains and losses in pasture and cropland appear to drive land-use change dynamics in the State. The forest land that was lost went mostly to agricultural uses and may be a result of increased commodity prices for corn during 2011-2013, increased demand for agriculture-based biofuels, or other possible causes. Iowa is one of the primary producers of ethanol in the United States. More than 50 percent of the national production of ethanol is attributed to the top-producing Corn Belt states of Iowa, Nebraska, and Illinois (Schnepf 2013). With increased interest in domestic fuel sources, there may be increased demand for suitable cropland.

Gains in forest land may come from reverting agricultural land, especially land close to streams. The State's public and private sectors have made a concerted effort to prioritize the reforestation of these riparian areas. Agroforestry efforts promote the maintenance of tree cover in the form of windbreaks and forest buffers, which help sustain a high agricultural output while conserving and protecting Iowa's soil and water resources. These forested areas are also important to Iowa's wildlife populations. Riparian forests often connect to form wildlife corridors, which may allow for greater species movement.

Some of the diversion and reversion of forest land in Iowa are probably the result of marginal forest land moving into and out of the forest land base. This movement between forest and nonforest classifications may be a result of land meeting or not meeting FIA's definition of forest land due to small changes in understory disturbance,

forest extent, or forest cover. These changes are generally not permanent and may be more prevalent in stands of small diameter trees (small stand-size class). The fact that much of the forest change in Iowa is occurring in stands of smaller diameter trees may support the idea that this type of nonpermanent land-use change is occurring in the State.

More forest land was lost to other land uses than was gained, which is a change from the results of the last inventory cycle from 2008 (Nelson et al. 2011). The difference in net change between the two inventory periods can be attributed primarily to a drop in the amount of nonforest land that reverted to forest; the amount of gross forest loss remained fairly stable between the two inventory cycles. The resulting net loss of forest land in this most recent inventory is relatively small and represents little appreciable net change in forest land area. The extent of forest cover may be starting to stabilize in Iowa after a period of growth since the 1970s.

Forest Ownership

Background

Ownership patterns are important because forest owners ultimately control the forest resources and decide how they will be managed. FIA collects inventory data across all ownership categories, both public and private. Family forest owners—families, individuals, and other unincorporated groups—compose a dominant, diverse, and dynamic group of private owners in Iowa. By understanding these owners, we can better help them meet their forest management needs, and in so doing, help conserve Iowa's forests for generations to come. FIA conducts the National Woodland Owner Survey (NWOS) in order to better understand who owns America's forests, why they own it, what they have done with it in the past, and what they intend to do with it in the future. NWOS summaries reported here are based on the responses from randomly selected Iowa family forest owners, with 10 or more acres of ownership, surveyed between 2011 and 2013 (n=138) (Butler et al. 2016b).

What we found

From the Missouri River bluffs in the west, through the small woodlots in the State's agricultural heartland, to the deeply dissected Driftless Area near the

Mississippi River to the east, forest ownership varies across Iowa (Fig. 8). An estimated 95,000 family forest owners control 81 percent of the forest land in Iowa, in 48,000 ownerships of at least 10 acres¹ (Fig. 9). According to the results of NWOS, the average size of the family forest holdings is 47 acres (Fig. 10). There are many reasons for owning forest land, the top five of which are related to wildlife habitat protection, aesthetics, protection of nature, protection of water resources, and as part of the family's home (Fig. 11). Timber production was ranked as important by only 15 percent of ownerships and 23 percent of acreage. Eleven percent of the family forest ownerships have a written management plan, and 17 percent have received forest management advice. The following issues were of great concern or concern for at least 50 percent of ownerships: high property taxes, keeping land intact for future generations, trespassing or poaching, unwanted insects or diseases, and misuse of forest/woodland, such as dumping. The most frequently listed forestry activities (by percentage of ownerships) planned for the next 5 years are: cutting and removing trees for own use (47 percent), improving wildlife habitat (38 percent), eliminating or reducing invasive plants (36 percent), collecting nontimber forest products (29 percent), and grazing livestock (29 percent). About 1 in 10 ownerships is owned by someone who plans to pass the land on to heirs or sell it within the next 5 years.

¹ The minimum size of a family forest ownership is 10 acres, a constraint not applied to the 147,000 family forest owners estimated in the 2008 report. Therefore, the 2008 and 2013 estimates are not directly comparable.

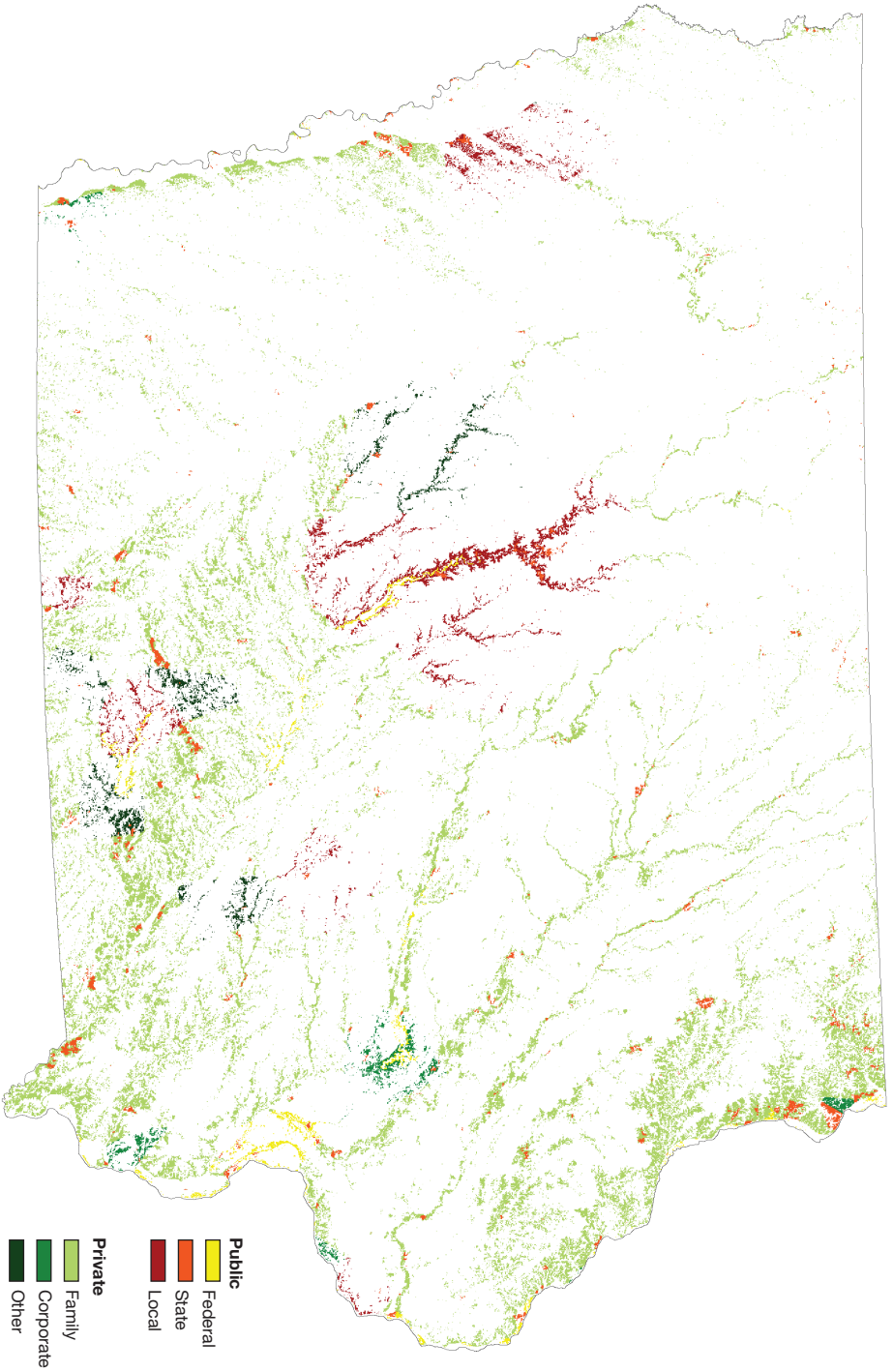


Figure 8.—Distribution of six forest ownership types, Iowa, 2009. Data source: Hewes et al. (2014).

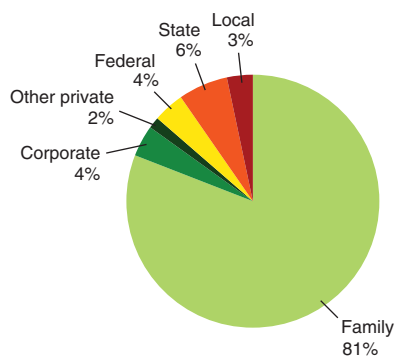


Figure 9.—Percentage of forest land and woodland by ownership category, Iowa, 2013.

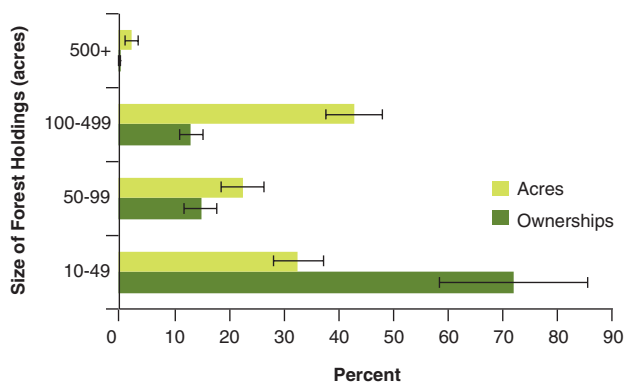


Figure 10.—Area and number of family forests by size of forest landholdings, as a proportion of the total, and associated sampling error, Iowa, 2013. Error bars represent a 68 percent confidence interval around each estimate.

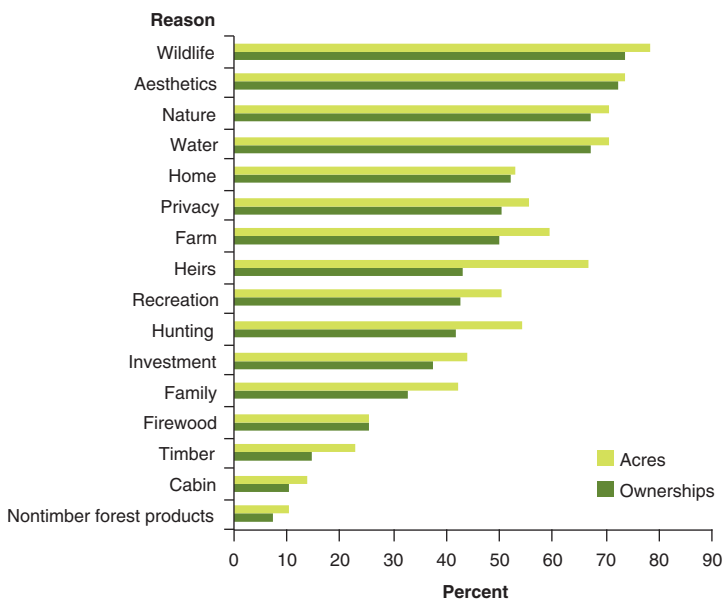


Figure 11.—Reasons for owning forest land by percentage of area owned and number of family forests, Iowa, 2013. These proportions refer to landowners who ranked each objective as very important or important on a 7-point Likert scale. Categories are not exclusive.

What this means

Much land will soon be changing legal ownership. Family legacy—keeping land intact for future generations—is an important ownership objective and also a major concern to both landowners and natural resource managers. What can be done to help the landowners and the land? Timber production is not the primary goal of family forest owners, but it is clear that many landowners are harvesting timber and firewood on their ownerships. How can natural resource professionals better communicate with family forest owners and help them better manage their woods? Iowa’s forest is diverse; so too are the people who own it. It is important to provide information that meets the landowners’ needs. General statistics are good for a broad overview, but we need to better understand the different types of owners, their attitudes, and their behaviors, as well as effective and efficient ways of communicating with them. One such attempt at learning more about landowners is through the Sustaining Family Forests Initiative (SFFI). For more information, visit www.sustainingfamilyforests.org.

Biomass

Background

Measures of total biomass and its allocation among stand components (e.g., large diameter and small diameter trees, limbs, stumps), help us understand the components of a forest stand and the resources available for different uses (e.g., biofuels, wildlife habitat, carbon sequestration).

What we found

The quantity of aboveground live-tree biomass on Iowa timberland has increased at a steady rate since 1990, exceeding 107 million oven-dry tons by 2013 (Fig. 12). This increase corresponds to an increase in timberland area, with biomass per acre increasing at a slower rate (Fig. 12). Most forest biomass in 2013 is in tree boles (61 percent), followed by belowground, tops and limbs, saplings, and stumps (Fig. 13). The largest amounts of Iowa forest biomass are located in the northeast, southeast, and south-central portions of the State (Fig. 14).

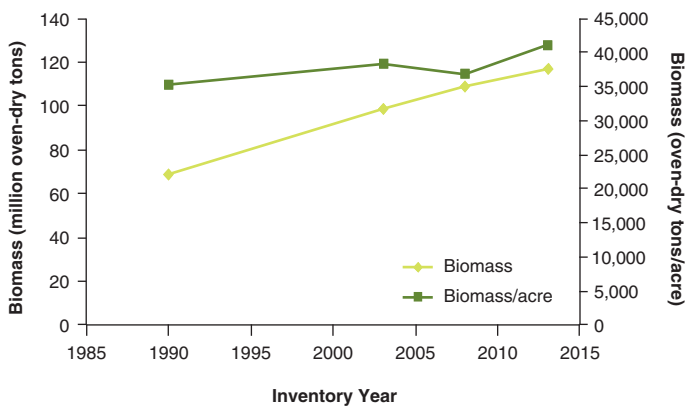


Figure 12.—Aboveground live-tree and sapling biomass on timberland, Iowa, 1990, 2003, 2008, and 2013.

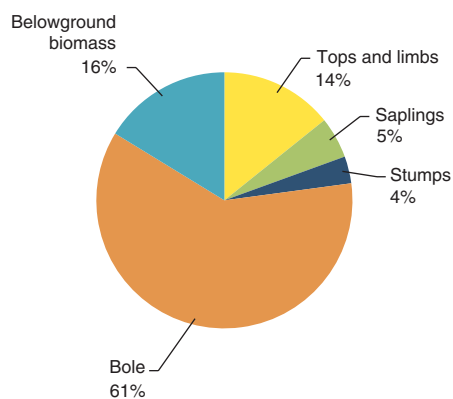


Figure 13.—Aboveground live-tree and sapling biomass on timberland by component, Iowa, 2009-2013.



Figure 14.—Distribution of aboveground live-tree biomass on forest land, Iowa, 2009. Data source for biomass: Unpublished data on file with B. Tyler Wilson, U.S. Forest Service, St. Paul, MN. Geospatial dataset produced by using the raster mapping methods described in Wilson et al. (2012).

What this means

Although total area of forest land and of timberland show a slight decrease, forest growth has resulted in a sustainable statewide resource of total forest biomass. Because timberland tree boles contain the most tree biomass, the management of private forest land strongly influences the future of not only the biomass resource but also the carbon cycles and future wood availability. Given the increasing desire to manage forest biomass components for both carbon and bioenergy use, the monitoring of Iowa's forest biomass becomes even more critical.

Tree Species Composition

Background

Tree species composition within forests is constantly changing, influenced by the presence or absence of disturbances such as timber management, recreation, wildfire, prescribed burning, extreme weather, and invasive species. As a result, the composition of species in a forest is an indicator of forest health, growth, succession, and need for stand improvement or other management. Knowledge of the distribution of species allows for the measurement and prediction of change.

What we found

About 1.08 billion trees were estimated on Iowa forest land in 2013, a slight decrease from the 2008 estimate of 1.16 billion trees. At least 60 tree species were observed on Iowa forest land in 2013. Of the total number of trees statewide, American elm, eastern hophornbeam, hackberry, and mulberry (including both red mulberry—a native species, and white mulberry—a nonnative species) were the four most numerous species, each estimated to have more than 50 million trees (Fig. 15). There were no oak species in the 12 most numerous species in 2013. However, several oak species are among the 12 species with the highest total statewide live-tree volume on forest land. Bur oak ranked the highest in terms of volume, containing nearly half a billion cubic feet of volume (Fig. 16). Black walnut is ranked seventh in terms of number of trees (Fig. 15), but compared with estimates for the surrounding states of Minnesota, Wisconsin, Illinois, Indiana, Missouri, Kansas, and South Dakota during 2008-2012 (the most recent year available for all states), Iowa's black walnut resource

ranks first in number of trees per acre on timberland: 12.9 trees per acre for all live trees of at least 1 inch d.b.h., and 5.6 trees per acre for growing-stock trees (Nelson and Brewer 2014).

Due to larger sampling errors associated with estimates for some individual tree species, comparisons across time are made for groups of related species. Most species groups had substantial increases in volume between 1990 and 2003, and a slightly increasing trend in total statewide live-tree volume during the past 10 years (Fig. 17). Notable exceptions were cottonwood and aspen, soft maple, and other eastern softwoods species groups, which all show declining patterns.

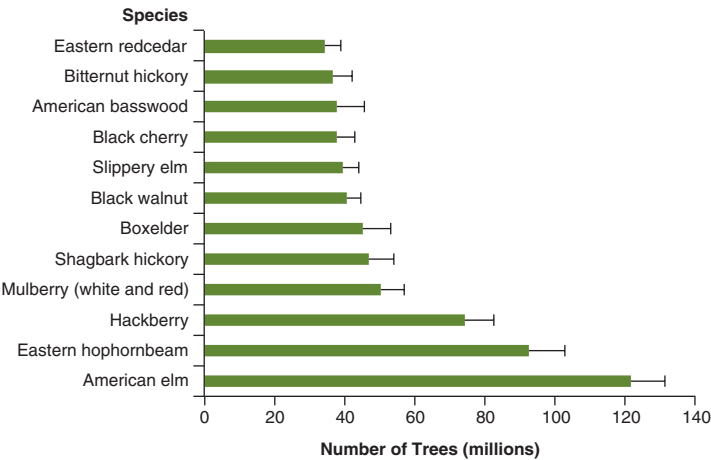


Figure 15.—Twelve most abundant tree species ranked by number of live trees on forest land, and associated sampling error, Iowa, 2009-2013.

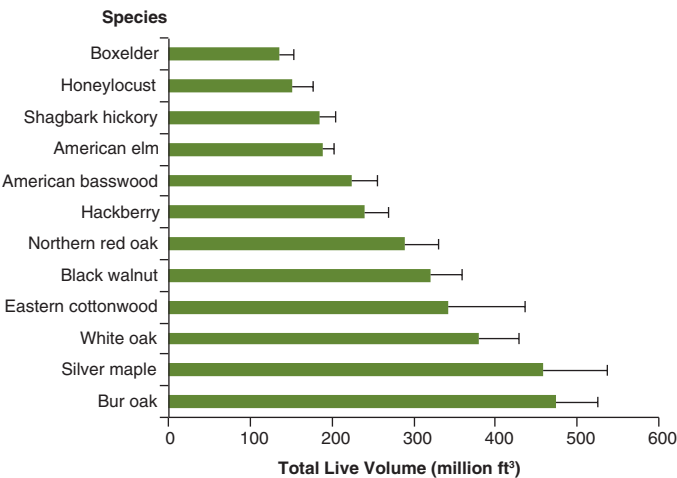


Figure 16.—Twelve tree species with the highest volume of live trees on forest land, and associated sampling error, Iowa, 2009-2013.

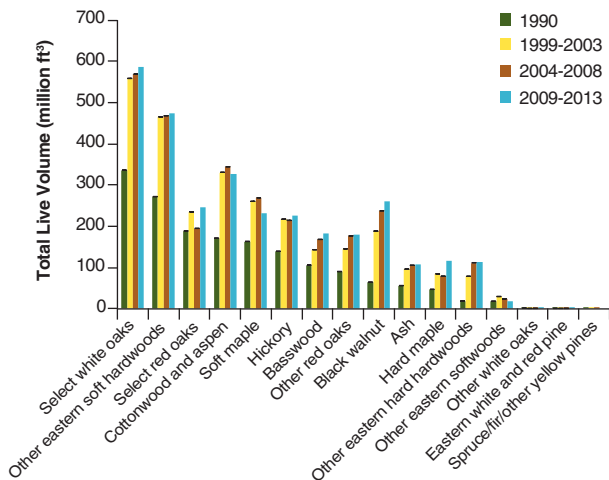


Figure 17.—Growing-stock volume on timberland by inventory year by tree species or species group, Iowa.

What this means

Iowa possesses a great diversity of tree species that will undoubtedly fill niches vacated by other species as forest ecosystems continue to evolve through the decades. As a group, select white oaks dominate the State in terms of total volume, even though no individual species of oak is represented among the dozen most populous species according to tree counts. This shows that many of the oak trees are large in size, indicating a maturing forest resource with sparse regeneration. (See further discussion in Regeneration Status section on p. 64.) In contrast, eastern hophornbeam, the second most numerous tree species (92 million), was ranked 29th overall in terms of volume. Repeated inventories reveal that species composition of Iowa's forests is changing, with some species increasing their dominance while others are decreasing in dominance.

Tree Density, Size, and Stocking

Background

Tree density is the ratio of the number of trees to a specific area, such as trees per acre. Tree size typically is referred to in terms of height or diameter. Height is affected by a combination of tree species, age, and the productivity of a site. Tree diameter is also affected by species and age; the other major determinant of diameter is tree density or stocking. Tree diameter is easily and accurately measured and is used to assign stand-size class. Here, stand size refers not to the area of a forest stand, but to the diameter of trees within a stand. Stand-size classes are defined as large—where a plurality of stocking is in hardwoods 11 inches d.b.h. and larger and softwoods 9 inches d.b.h. and larger; medium—where a plurality of stocking is in softwood trees from 5 to 9 inches d.b.h. and hardwood trees from 5 to 11 inches; or small—where a plurality of stocking is in trees less than 5 inches d.b.h. Tree diameter also can be used to compute tree basal area—the cross-sectional area of a tree bole at breast height (4.5 feet).

Stocking provides information on the degree of occupancy of land by trees compared with a desired level for balanced health and growth. Stocking levels are calculated by using a combination of number of trees, species, sizes, and spacing. Stocking is very important for determining and assessing forest management practices. A fully stocked stand indicates full utilization of the site. In stands of trees at least 5 inches d.b.h., a fully stocked stand would typically have a basal area of greater than 80 square feet per acre. In a seedling-sapling stand a fully stocked stand would indicate that the present number of trees is sufficient to attain a basal area of at least 80 square feet per acre when the trees are more than 5 inches in diameter.

What we found

The density of Iowa's timberland trees increased from 60 growing-stock trees per acre during the 1950s to 78 in 2003, then declined slightly to a relatively stable density of about 68 trees per acre (Fig. 18). Basal area of growing-stock trees per acre of timberland increased from about 41 in 1954 to 53 in 2003, then decreased to the current estimate of 51. (Note that in the previous report, these results included growing-stock trees between 1 and 5 inches d.b.h.; here we include only growing-stock trees of at least 5 inches d.b.h.)

More than two-thirds (69 percent) of forest land in Iowa is in the large diameter stand-size class, 18 percent is medium diameter, and the remaining 13 percent is in

either the small diameter or nonstocked class. Just over one-third (36 percent) of Iowa’s forest land is fully stocked or overstocked, 43 percent is medium stocked, and 22 percent is poorly stocked or nonstocked. By combining these two classifications we see that large diameters compose the majority of all stocking classes in Iowa, with the greatest percentage of large diameters in fully stocked stands (about 75 percent). Small diameters are most prevalent in overstocked stands, and the largest percentages of medium diameters are in medium and poorly stocked stands (Fig. 19).

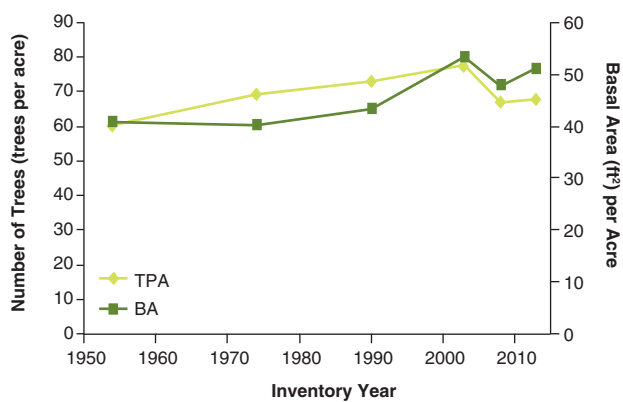


Figure 18.—Average number of growing-stock trees per acre (TPA) and average basal area (BA) per acre for growing-stock trees of at least 5 inches d.b.h. on timberland, Iowa, 1954-2013.

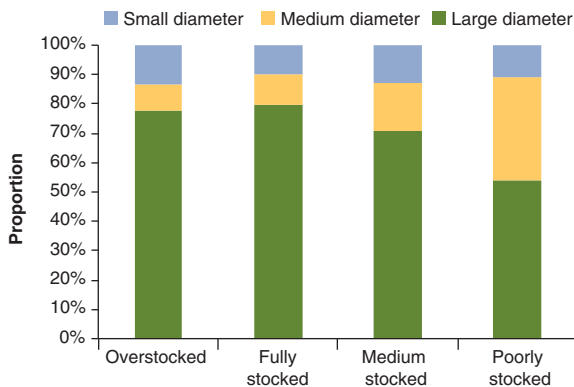


Figure 19.—Proportion of forest land area by stocking class and stand-size class, Iowa, 2009-2013.

What this means

The density and diameter of trees across Iowa provide information on the stages of forest stand development and stocking levels. Since 1954, both the number of trees per acre and basal area per acre of growing-stock trees (of at least 5 inches d.b.h.) have increased, reflecting positive stewardship and conservation of Iowa's forest resources. The dynamics between the number of trees per acre and average diameter or basal area per acre present evidence of a maturing forest resource across Iowa. This trend may be expected to continue until stands reach a state of senescence or when they are affected by disturbances, either human induced (e.g., removals) or naturally occurring (e.g., windstorm, fire). However, nearly a quarter of forest land in Iowa is understocked or nonstocked, presenting an opportunity for additional management. (But see discussion of ownership objectives in Forest Ownership section on p. 18.)

Tree Growth

Background

A stand's capacity for growth, that is, for trees to increase in volume, is an indication of the overall condition of the forest and more specifically of tree vigor, forest health, and successional stage. Forest growth is reported as net growth, where net growth is equivalent to gross growth minus mortality. Average annual net growth represents an average for the annual change in volume between the two most recent inventories, 2008 and 2013.

What we found

Average annual net growth of growing-stock trees on Iowa's timberland decreased from about 68 million cubic feet per year in 1954 to about 41 million cubic feet in both 1974 and 1990, followed by a large increase to nearly 118 million cubic feet in 2003 and a decrease during the past decade to 71 million cubic feet (Fig. 20). The five species groups with the greatest average annual net growth were black walnut, select white oaks, other eastern soft hardwoods, cottonwood, and select red oaks, all of which exceeded 5 million cubic feet per year (Fig. 21). Black walnut, other eastern hard hardwoods, and ash species groups all had ratios of annual net growth to volume exceeding 3 percent, with seven other species groups each exceeding 2 percent (Fig. 22).

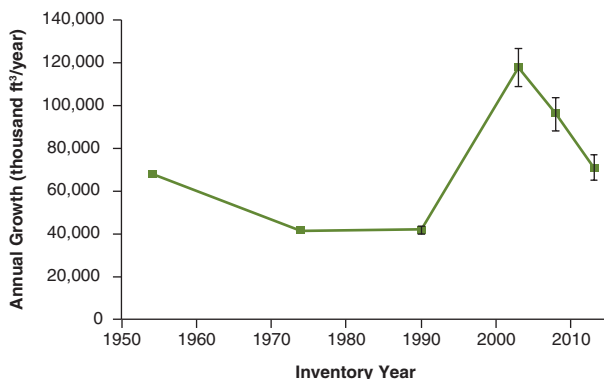


Figure 20.—Average annual net growth of growing stock on timberland, and associated sampling error, Iowa, 1954-2013. Error bars represent a 68 percent confidence interval around each estimate and are available only since 1990.

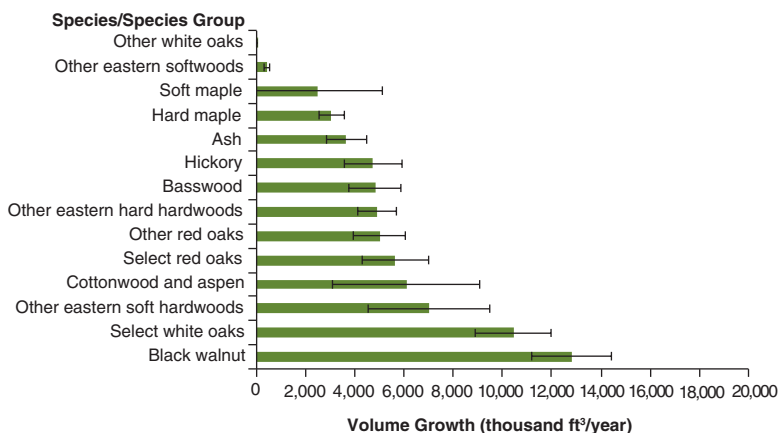


Figure 21.—Fourteen tree species or species groups ranked by average annual net growing-stock volume growth on timberland, and associated sampling error, Iowa, 2009-2013.

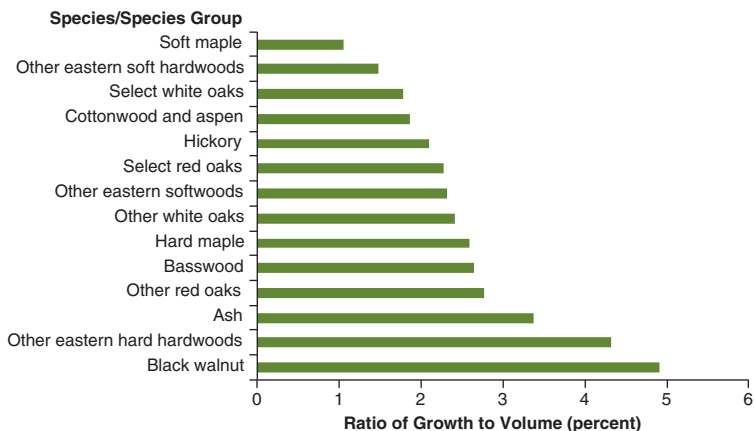


Figure 22.—Fourteen tree species or species groups ranked by average annual net volume growth expressed as a percentage of total growing-stock volume on timberland, Iowa, 2009-2013.

What this means

The net growth of Iowa's forests increased during past decades, but has been decreasing during the last 10 years. Many of the economically desirable tree species, such as oaks and walnut, continue to accrue tremendous annual growth. Black walnut shows the highest growth rate—relative to total volume—followed by other eastern hard hardwoods and ash; oaks show comparatively less relative growth.

Tree Mortality

Background

Tree mortality influences a number of forest characteristics such as health, vigor, and rate of accretion and depletion. Mortality can be caused by insects, disease, adverse weather, succession, competition, fire, old age, or human or animal activity either alone or in combination. Although timber utilization and land clearing also result in tree mortality, those actions are accounted for separately as “harvest removals” (see Tree Removals section on p. 35). Growing-stock mortality estimates represent the average cubic foot volume of sound wood in growing-stock trees that died each year as an average for the years between inventories.

What we found

The rate of average annual growing-stock volume mortality on Iowa's timberland was fairly level during 1954 and 1974 at about 0.6 percent, but has since increased to its current level of 1.5 percent (Fig. 23). In terms of total statewide average annual mortality, the other eastern soft hardwoods species group had almost 19 million cubic feet of mortality, the largest, by far, of any species group (Fig. 24). Cottonwood and soft maple species groups followed with 0.8 and 0.75 million cubic feet, respectively. Compared to total growing-stock volume on timberland for each species group, eastern white and red pine had the largest percentage of mortality at 38 percent (but confidence in this estimate is low, due to large sampling error). Other eastern soft hardwoods had a mortality rate of 4 percent, and all other species groups had a lower rate (Fig. 25).

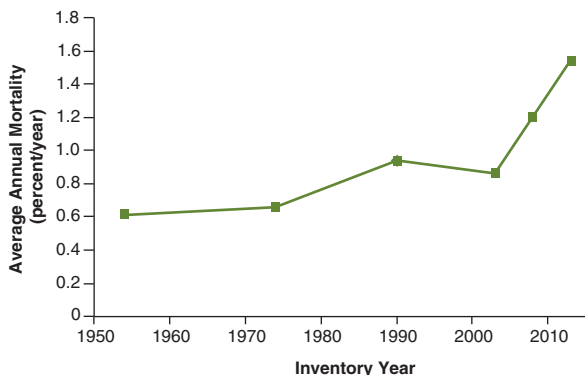


Figure 23.—Average annual net growing-stock volume mortality for total statewide growing-stock volume on timberland, Iowa, 1954-2013.

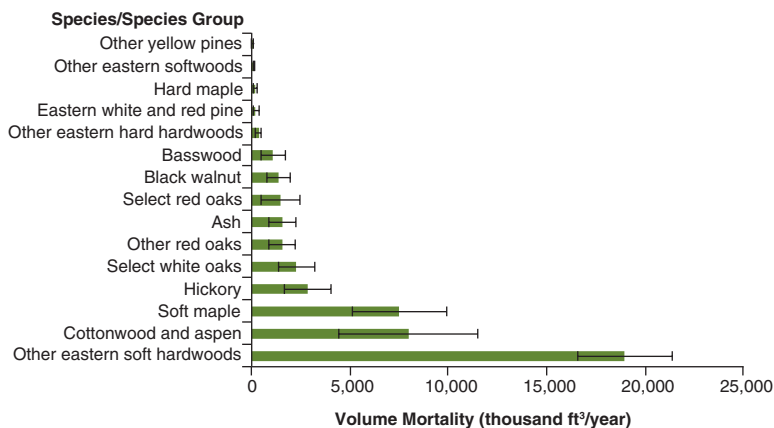


Figure 24.—Fifteen tree species or species groups ranked by average annual net growing-stock volume mortality on timberland, and associated sampling error, Iowa, 2009-2013. Error bars represent a 68 percent confidence interval around each estimate.

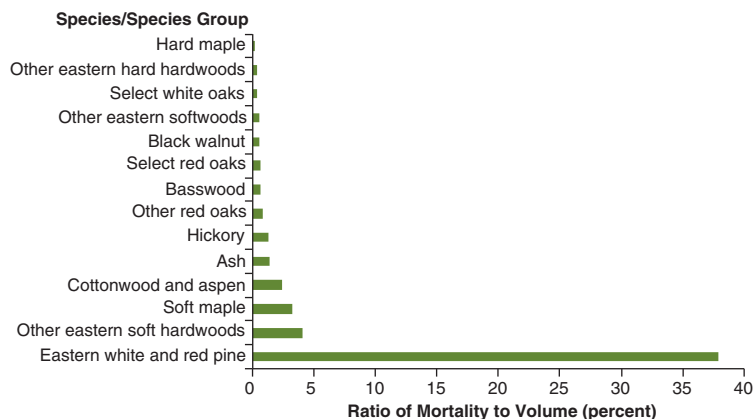


Figure 25.—Fourteen tree species or species groups ranked by average annual net growing-stock volume mortality as a percentage of total growing-stock volume on timberland, Iowa, 2009-2013.

What this means

The levels of tree mortality across Iowa are 2.5 times the rate during the 1950s, when removal rates were higher (see next section). Mortality is a natural process in forest stands as they develop and change over time. However, recent invasions by nonnative pests are increasing rates of mortality. Total mortality for other eastern soft hardwoods species group is more than double that of any other species group. Dutch elm disease is a major contributor to this high mortality rate; American elm is the most numerous tree species within this group. Other than for eastern white and red pine species group, which shows a very high rate of mortality (but subject to large sampling error), rates of growth exceed rates of mortality, often by a substantial margin. Tree mortality is a crucial component of overall forest health and thus should be monitored into the future.

Tree Removals

Background

Trees are removed from timberland to meet a variety of objectives. Changes in the quantity of growing stock removed help to identify trends in land-use change and forest management. Average annual removals of growing-stock volume on timberland can be classified as either “harvest removals” or “other removals.” As the name implies, the category “harvest removals” refers to trees harvested for timber products or for other forest management purposes. Also all trees cut or destroyed during changes in land use are considered “utilized” and are included in harvest removals. In contrast, “other removals” refers to a change in either land use or protection status, either from actual diversion of forest land to a nonforest land use or from the reclassification of forest land from timberland to “reserved” or “unproductive” forest land. Historical inventories were limited to timberland, and estimates of removals were limited to “annual cut” of sawtimber or growing stock. Because removals generally occur on only a small number of plots during each inventory, the estimates for removals show greater variance than those for growth, mortality, or area, which occur on nearly every plot. Like forest growth, the rate at which trees are removed represents the average annual growing-stock removals that occurred between 2008 and 2013 inventories.

What we found

Average annual harvest removals of growing-stock trees on timberland as a percentage of total statewide volumes was about 1.6 percent in 1954, increasing to 4.8 percent in 1974, then declining to 0.64 percent in the current inventory (Fig. 26). Most of the harvest removals were focused on species groups of soft maple, black walnut, other eastern soft hardwoods, cottonwood and aspen, other eastern hard hardwoods, select red oaks, and select white oaks, all of which had removals in excess of 1 million cubic feet per year (Fig. 27). Other removals were smaller than harvest removals for all species groups except cottonwood and aspen, where other removals accounted for 8.4 million cubic feet per year (Fig. 27). Average annual growing stock harvest removals as a percentage of total statewide volumes were greatest for soft maple, at 2.2 percent, with other eastern hard hardwoods and black walnut exceeding 1.5 percent per year (Fig. 28). Average annual growing stock other removals was largest for cottonwood and aspen, at 2.6 percent, with all other species groups below 1 percent (Fig. 29).

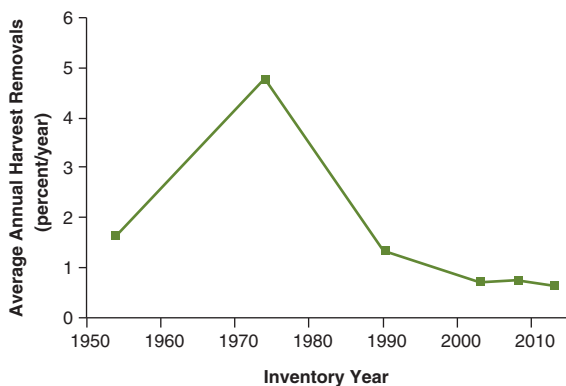


Figure 26.—Average annual harvest removals of growing stock as a percentage of total statewide growing-stock volume on timberland, Iowa, 1954-2013.

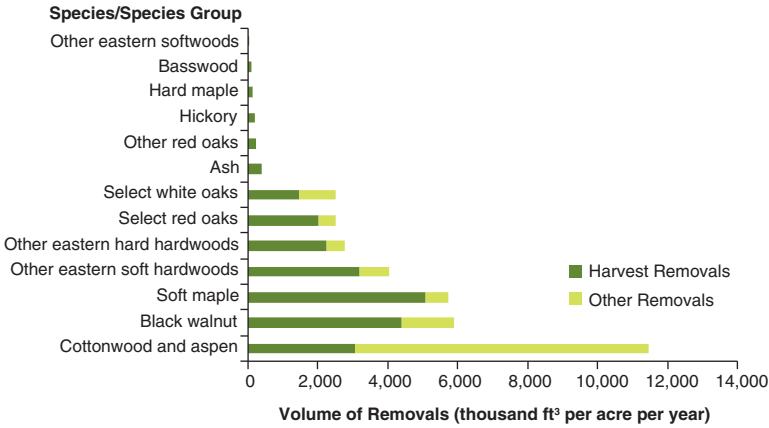


Figure 27.—Thirteen tree species or species groups ranked by average annual net growing-stock volume of harvest removals and of other removals per acre of timberland, Iowa, 2009-2013.

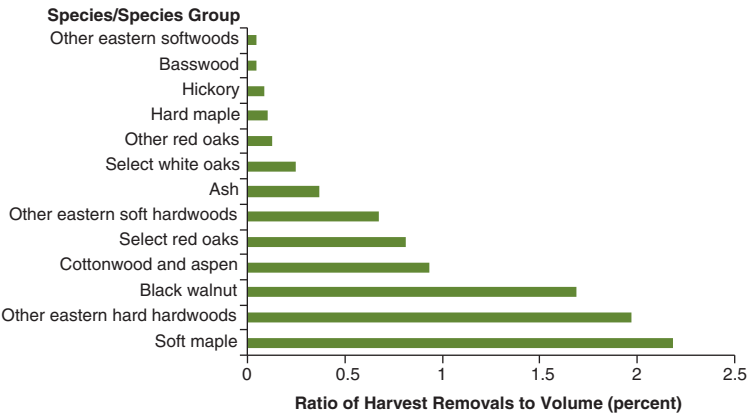


Figure 28.—Thirteen tree species or species groups ranked by average annual net volume harvest removals as a percentage of total growing-stock volume on timberland, Iowa, 2009-2013.

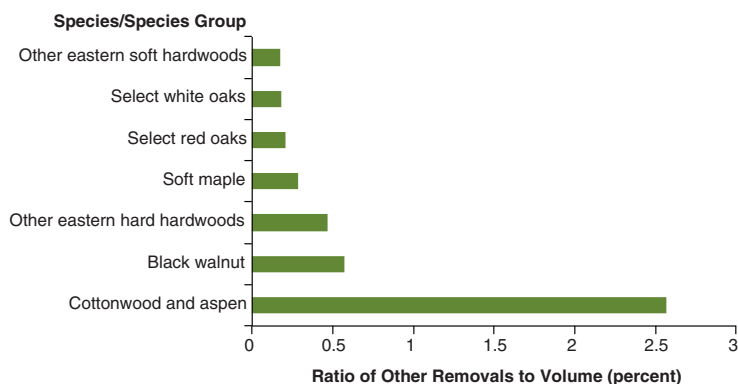


Figure 29.—Seven tree species or species groups ranked by average annual net volume of other removals (trees remaining after a land-use change) as a percentage of total growing-stock volume on timberland, Iowa, 2009-2013.

What this means

Removal rates are indicative of both harvest and land-use change. Average annual rate of removals (both harvest and other) for all species groups combined (1.2 percent per year) is slightly lower than that of mortality (1.5 percent per year) during 2009-2013. Annual net growth (gross growth minus mortality) averaged 2.3 percent of total volume, which is almost double the rate of removals, indicating that Iowa removals are sustainable. During the previous 5 years (2004-2008), the average annual net growth of 3.4 percent per year exceeded the previous rate of removals (1.2 percent) by a larger amount, suggesting that the current ratio of growth to removals is lower than during the previous inventory. However, these rates may not apply to local scales or for specific species. For example, silver maple, which predominates in the soft maple species group and is the species with the largest volume of harvest removals (5.1 million cubic feet per year), has a rate of harvest removals (2.2 percent per year) exceeding rate of net growth (1.1 percent per year). In contrast, black walnut, which is one of the most valuable species in the State, has a growth rate (4.9 percent per year) that greatly exceeds the rate of harvest removals (1.7 percent per year). There is an ongoing need to monitor removals on a species-by-species basis.

Forest Indicators



Ash tree infested with emerald ash borer, Lucas County, Iowa. Photo by Jeremy Cochran, Iowa Department of Natural Resources, used with permission.

Fragmentation and Urbanization of Forest Land

Background

In addition to direct loss of forest land due to conversion to other land uses, land development has a wider impact by increasing both the physical fragmentation and the urbanization of the remaining forested lands. Depending on the location of the development (or other activity), conversion from forest land to other uses can result in fragmenting remaining forest land. Changes in the size of remaining forest patches, in their level of connectivity to other large patches, in the amount of general forest cover surrounding each patch, and in the amount of forest–nonforest edge, all affect the quality of interior forest and the species and ecosystem functions that depend on interior conditions (Collinge 1996). These same factors also affect the ease with which exotic, invasive, or generalist species can gain a foothold, the ability of wildlife species to move across the landscape, and the ability of the forest to protect the quality and quantity of surface and ground water supplies.

Spatial landscape pattern metrics help quantify these different characteristics of fragmentation. In the last 5-year report (Nelson et al. 2011), we examined the amount of forest in edge versus core situations with respect to the most widely used thresholds for interpreting likely impact. Values of metrics are sensitive to the grain (spatial resolution) of the land cover data source used (Moody and Woodcock 1995), similar to the way that animal species see the landscape very differently depending on the scale at which they operate. For example, the same patch that supplies interior forest conditions for one species is viewed as an unsuitable fragment by another.

Important forest ecosystem processes operate at different scales, so in this report we examine current levels of fragmentation at two scales. We adapted a spatial integrity index (SII) developed by Kapos et al. (2000) for the Global Forest Resources Assessment that integrates three important facets of fragmentation affecting some aspect of forest ecosystem functioning—patch size, local forest density, and patch connectivity to core forest areas—to create a single resulting metric (SII) for comparison. Because even low misclassification rates in the source land cover data can be magnified into substantial errors in metric values (Langford et al. 2006, Shao and Wu 2008), we calculated spatial integrity at the two scales corresponding to two reliable and widely available source datasets: the 30 m (98.4 feet) scale of the 2011 National Land Cover Dataset (Homer et al. 2015), and the 250 m (820 feet) scale of the 2009 FIA forest cover dataset (Wilson et al. 2012). Both scales fall within the 10 to 1,000 km² (2,471 to 247,091 acres) scale at which linkages between patterns and processes are often of greatest management interest (Forman and Godron 1986).

Historically, portions of Iowa were home to oak savanna. This savanna was a matrix of prairie and trees, and thus not a completely closed tree canopy as is characteristic of forest land in other areas. Very little of this oak savanna is left, and only degraded remnants remain in the State (McGovern 2016). Depending on their tree canopy density, such forests may or may not be identified by the data sources and methods used in this analysis. Targeting those oak savanna forests would require data sources and methods more tuned to this intermix of forest and prairie.

In the SII calculation, core forest is defined by patch size and local forest density within a specified local neighborhood area. An unconnected forest fragment is defined by its patch size, local forest density, and distance to a core forest area, and the spatial integrity of all other forest lands is scaled between the forest fragment and the core forest area. Table 1 identifies the thresholds used to define both core forest and unconnected fragments, at the 250 m and 30 m scales, respectively.² These thresholds are based on minimum core area reported by Kapos et al. (2000) (minimum of 100 km² core area when using 1 km pixel resolution), rescaled to our pixel resolutions of 30 m and 250 m.

Table 1.—Spatial integrity index (SII) parameters used in calculations at each scale

	Scale	
Definition of Core	250 m (820 ft)	30 m (98 ft)
Patch size	>1,544 acres	>22 acres
Local forest density	90%	90%
Neighborhood radius	0.78 mile	0.09 mile
	Scale	
Definition of Unconnected Fragment	250 m (820 ft)	30 m (98 ft)
Patch size	<30 acres	<2.5 acres
Local forest density	≤10%	≤10%
Neighborhood radius	0.78 mile	0.09 mile
Distance to core	>4.2 miles	>0.5 miles

These two scales capture a fairly broad range of definitions for core forest and spatial integrity that should encompass the scales appropriate for understanding impacts on a wide range of wildlife species and ecosystem processes affected by forest fragmentation in Iowa. At the 250 m scale where a patch must be 1,544 acres in size and have a local forest density of 90 percent within a 0.78-mile-radius circle, most of Iowa’s forest land does not qualify as core forest or forest with high spatial integrity. However, when examined at the 30 m scale, where a patch must be 22 acres in size and have 90 percent tree canopy cover within a 0.09-mile-radius circle, there are several counties with a substantial proportion of core or high-integrity forest land remaining. These areas of

2 Unpublished data on file with Rachel Riemann, Troy, NY.

forest land suggest an opportunity for planning that would retain their spatial integrity. In many areas, increasing the amount of tree cover in the surrounding landscape, and in particular creating additional connectivity of forest land between existing patches, would increase the spatial integrity of remaining forest land.

What the SII identifies as core does not represent completely intact forest conditions because it is calculated from forest canopy alone and does not take into consideration underlying house densities or proximity to roads. Using Radeloff et al.'s (2005) definition of Wildland Urban Intermix areas (greater than 15.5 housing units per square mile [6.17 housing units per km²]), we identified how much forest, and particularly SII core or intact forest land, coincided with these intermix areas. The wildland-urban interface (WUI) is described as the zone where human development meets or intermingles with undeveloped wildland vegetation, and it is associated with a variety of human–environment conflicts. Radeloff et al. (2005) defined this area in terms of the density of houses (WUI “intermix” areas), the proximity to developed areas (WUI “interface” areas), and percentage of vegetation coverage present. We used maps of WUI intermix areas intersected with forest land in the 2011 National Land Cover Dataset (Fig. 30) to examine changes in the amount of forest land co-occurring with WUI house densities.

What we found

The human population of Iowa increased by 4.1 percent to 3.05 million between 2000 and 2010. During that same time the number of housing units increased by 8.9 percent (U.S. Census Bureau 2011); that is, over those 10 years the increase in housing units occurred at a pace 2.5 times the rate of increase in population, a trend not limited to Iowa. In recent decades this housing growth has occurred not only in increasing suburban rings around urban areas but also in rural areas. Lepczyk et al. (2007), Theobald (2005), and Hammer et al. (2004) observed that the areas facing particularly rapid increases in housing density currently and into the future were amenity-rich rural areas around lakes and other recreation areas. The 27.6 percent increase in the number of reported second homes in Iowa from 2000 to 2010 (21,020 units) could be a partial reflection of this trend. This may put additional pressure on forested areas even above the general increases in population density and housing density.

When we calculated SII classes for forest land in Iowa at the 250 m scale (in which core forest is defined as 1,544 acres and greater), 1 percent of the forest land is core forest, 6 percent has high spatial integrity, 6 percent has medium integrity, 1 percent has low spatial integrity, and 87 percent of the forest is in unconnected fragments

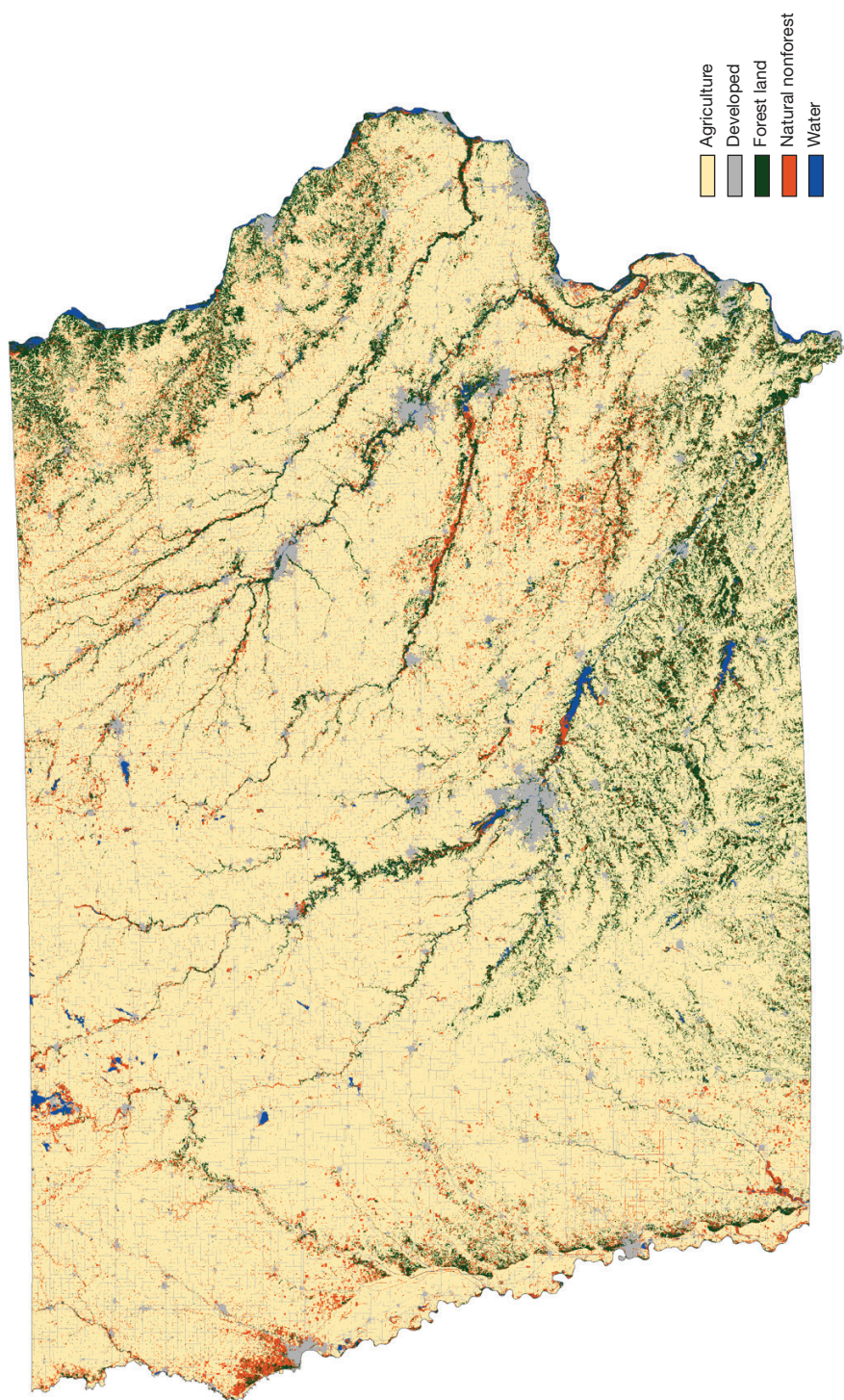


Figure 30. — Iowa land cover, 2011. Data source: National Land Cover Database 2011 (Homer et al. 2015).

(total does not sum to 100 percent due to rounding error) (Table 2). At the 30 m scale, with 22 acres or greater considered core forest, 20 percent of the forest land in Iowa is core forest, 20 percent has high integrity, 12 percent has medium integrity, 1 percent has low integrity, and 47 percent of the forest is in unconnected fragments (Table 2). Forest connectivity is highest in the Northeastern and Southeastern Units and lowest in the Northwestern Unit (Fig. 31). Figure 32 compares the SII classes between the two scales for a four-county area in the northeastern corner of Iowa. It is important to note that the forest land datasets being used are depicting tree cover only and do not fully incorporate the presence of any development that might be associated with or underlying this tree cover. As we take this caveat into account in the following analysis, it is evident that some housing development incursions (e.g., WUI) into these areas are happening.

Table 2.—Percentage of forest cover by spatial integrity index (SII) class and FIA unit, at 30 m (2011) and 250 m spatial resolution, and adjusted for wildland-urban interface (WUI), Iowa

Unit	Proportion of forest land by 30 m (98 ft) spatial integrity class					Proportion of forest land by 250 m (820 ft) spatial integrity class				
	Forest fragment	Low SII	Medium SII	High SII	Core forest	Forest fragment	Low SII	Medium SII	High SII	Core forest
Northeastern	36%	2%	14%	23%	25%	80%	2%	9%	7%	2%
Southeastern	46%	1%	12%	21%	20%	91%	0%	3%	4%	1%
Southwestern	73%	1%	5%	11%	10%	85%	1%	5%	8%	1%
Northwestern	79%	1%	6%	9%	5%	100%	0%	0%	0%	0%
Iowa	47%	1%	12%	20%	20%	87%	1%	6%	6%	1%
Iowa after incorporating WUI areas	47%	2%	12%	21%	18%	87%	1%	6%	6%	1%

Unlike many states, Iowa’s forest land does not appear to be immediately threatened by urban development. The amount of forest land with sufficient underlying housing density to qualify as WUI areas has been steadily increasing, but is still a small proportion of the total forest land in Iowa (Table 3). In 1990, 4 percent of Iowa’s forest land was in low- and medium-density WUI. In 2000 this share increased to 5 percent of the forest land, and in 2010 it was 6 percent of the forest land. Worth noting, however, is that when we integrate SII results at the 30 m scale with the WUI classes, a third of this 6 percent is affecting Iowa’s core forest, reducing it from 20 percent to 18 percent of the forest land in Iowa at the 30 m scale.

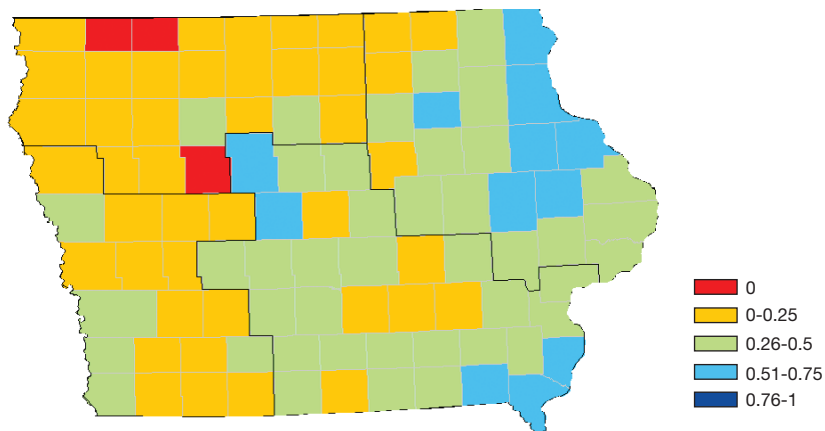


Figure 31.—Proportion of forest land in core (spatial integrity index [SII] = 10) or high integrity (SII = 7 to 9) forest conditions at the 30 m scale, Iowa, 2011. Data source: National Land Cover Database 2011 (Homer et al. 2015).

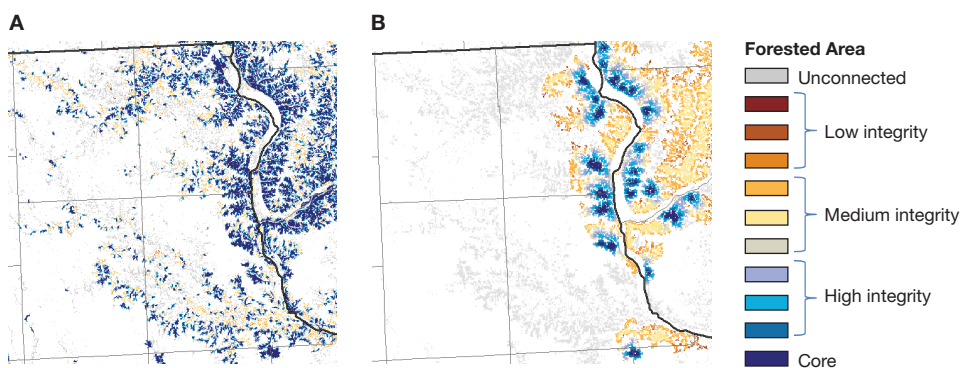


Figure 32.—Forest land by spatial integrity index (SII) at the 250 m scale (A) and 30 m scale (B) in the northeastern four counties, Iowa, 2009 or 2011. Data source for 250 m scale: Unpublished data on file with B. Tyler Wilson, U.S. Forest Service, St. Paul, MN; for 30 m scale: National Land Cover Database 2011 (Homer et al. 2015).

Table 3.—Proportion of forest land in the wildland-urban intermix, by FIA unit, Iowa, 1990-2010

Unit	Proportion of forest land		
	1990	2000	2010
Northeastern	5%	7%	8%
Southeastern	3%	4%	5%
Southwestern	4%	5%	5%
Northwestern	2%	3%	3%
Iowa	4%	5%	6%

What this means

Overall, forest makes up about 8 percent of Iowa's land base. How this forest land is arranged across the landscape affects ecological processes. From its forest-prairie history, Iowa's forest is currently primarily distributed within a matrix of agricultural land uses. Within that setting, we examined the spatial integrity of Iowa's forest lands, and the extent of additional urban pressures. Based on the map pixel analysis, 1 percent of the area of Iowa's forest is in core conditions forest when assessed at 250 m resolution, and 20 percent is core at 30 m resolution. These results indicate that the remaining forest land in Iowa is heavily fragmented at multiple scales of analysis. Overall forest pattern varies considerably across the State, as did historical forest cover. Northeastern and southeastern counties contain the bulk of the forest land in Iowa and also the least fragmented forest. However, even these counties contain substantial proportions of forest patches with no more than low spatial integrity (38 percent and 47 percent of forest land in the northeastern and southeastern counties, respectively) at our smallest unit of analysis. This degree of fragmentation has serious implications for these forest patches. Much of this forest is likely to be susceptible to negative edge effects, such as invasion by nonnative invasive species, a situation which makes it harder to maintain biodiversity and healthy populations of native plants and wildlife.

Tree Crown Health and Damage

Background

The crown condition of trees is influenced by various biotic and abiotic stressors. Biotic stressors include native or introduced insects, diseases, invasive plant species, and animals. Abiotic stressors include drought, flooding, cold temperatures or freeze injury, nutrient deficiencies, soil physical properties affecting soil moisture and aeration, and toxic pollutants.

Invasions by exotic diseases and insects are one of the most important threats to the productivity and stability of forest ecosystems around the world (Liebhold et al. 1995b, Pimentel et al. 2000, Vitousek et al. 1996). Over the last century, Iowa's forests have suffered the effects of native insect pests such as forest tent caterpillar (*Malacosoma disstria*) and the well-known exotic and invasive agent Dutch elm disease (*Ophiostoma ulmi*), among many others. More recently, invasions by the

emerald ash borer (*Agrilus planipennis*) and gypsy moth (*Lymantria dispar*) are threatening the health of trees. Additionally, although Asian longhorned beetle (*Anoplophora glabripennis*) and thousand cankers disease (*Pityophthorus juglandis* and its fungal associate *Geosmithia morbida*) have not yet been discovered in Iowa, they have been discovered in neighboring states.

Data on tree-level crown dieback are collected on P2+ plots (a subset of FIA Phase 2 plots, on which additional measurements are taken). Crown dieback is defined as recent mortality of branches with fine twigs and reflects the severity of recent stresses on a tree. A crown was labeled “poor” if crown dieback was greater than 20 percent. This threshold is based on findings by Steinman (2000) that associated crown ratings with tree mortality. Additionally, crown dieback has been shown to be the best FIA crown variable to use for predicting tree survival (Morin et al. 2012).

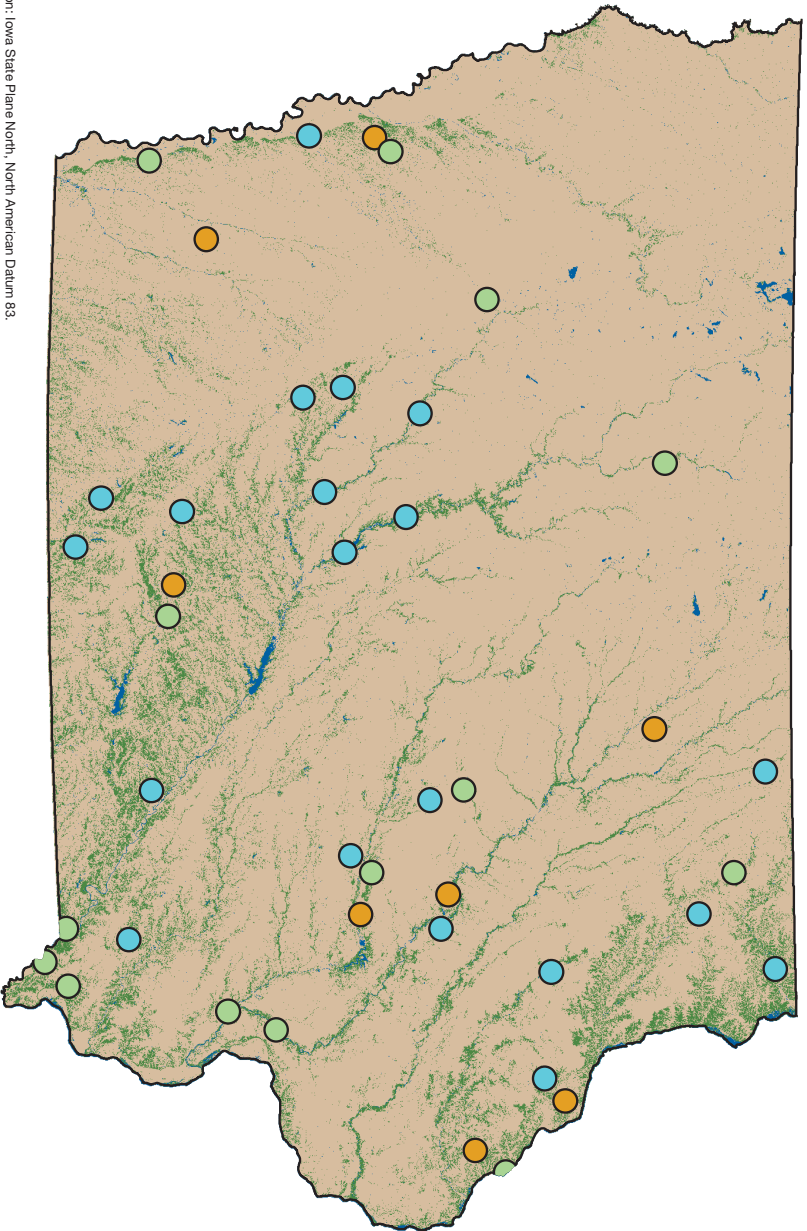
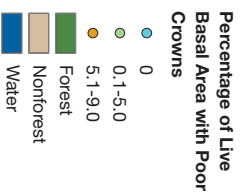
Tree damage is assessed for trees at least 5.0 inches d.b.h. Up to three types of damage can be recorded. If more than three damage agents are observed, decisions about which three to record are based on the relative abundance of the damaging agents (U.S. Forest Service 2010). The types of damage that are recorded include defoliation, foliage disease, cankers, decay, rot, fire, animal damage, weather, and logging damage.

What we found

The incidence of poor crown condition is low across Iowa with no discernable spatial pattern (Fig. 33). The only species with more than 5 percent of live basal area containing poor crowns is American elm (Table 4). Mean dieback ranged from 1 percent for shagbark hickory to 13 percent for American basswood (Table 5).

Figure 34 shows the proportion of remeasured trees that survived, died, or were cut in crown dieback classes based on the health of the crowns at the previous measurement. The proportion of the trees that died increased with increasing crown dieback. Nearly 50 percent of trees with crown dieback above 20 percent during the 2008 inventory were dead when visited again during the 2013 inventory.

Damage was recorded on about 28 percent of the trees in Iowa, but there is considerable variation between species (Table 6). Because of Dutch elm disease, elm species have the highest mortality rate of all species in the State. The most frequent damage on all species was decay (17 percent of trees), but it ranged from 4 percent on American elm to 29 percent on silver maple. Damage from animals was noted on 17 percent of silver maple trees. The occurrence of all other injury types was very low (Table 6).



Projection: Iowa State Plane North, North American Datum 83.
 Sources: U.S. Forest Service, Forest Inventory and Analysis program, 2013 and NLCD, 2006.
 Geographic base data are provided by the National Atlas of the USA. FIA data and tools are available
 online at www.fia.fs.fed.us/tools-data/.
 Cartography: R.S. Morn, U.S. Forest Service, Jan. 2015.

Figure 33.—Percentage of live basal area with poor crowns, Iowa, 2009-2013. Depicted FIA plot locations are approximate.

Table 4.—Percentage of live basal area with poor crowns, Iowa, 2008 and 2013

Species	Proportion of Basal Area with Poor Crowns	
	2008	2013
American elm	7.1%	7.3%
American basswood	0.0%	4.7%
Silver maple	5.0%	2.5%
White oak	2.1%	1.8%
Bur oak	0.6%	0.6%
Cottonwood	33.6%	0.0%
Shagbark hickory	13.8%	0.0%
Black walnut	0.7%	0.0%
Hackberry	0.0%	0.0%
Northern red oak	0.0%	0.0%

Table 5.—Mean crown dieback and other statistics for live trees (at least 5 inches d.b.h.) on forest land by species, Iowa, 2013

Species	Trees	Mean	SE	Minimum	Median	Maximum
	<i>number</i>	<i>percent</i>				
American basswood	36	12.5	4.6	0	5	95
American elm	56	8.6	2.3	0	5	99
White oak	22	6.1	2.8	0	5	65
Bur oak	55	6.1	1.8	0	5	99
Silver maple	64	6.0	0.7	0	5	40
Northern red oak	11	4.1	0.9	0	5	10
Cottonwood	14	3.9	0.9	0	5	10
Hackberry	45	3.3	0.4	0	5	5
Black walnut	25	2.0	0.5	0	0	5
Shagbark hickory	32	1.3	0.4	0	0	10

What this means

The trees of the most important species in Iowa’s forests are generally in good health, but substantial dieback was observed in American elm. Poor crown health in American elm is most likely due to the impacts of Dutch elm disease. The health of ash species, oak species, maple species, black walnut, and butternut should be monitored closely in the face of recent and likely future invasions by emerald ash borer, gypsy moth, Asian longhorned beetle, and thousand cankers disease. As in most eastern forests, decay is the most commonly observed damage in Iowa’s forests, an expected finding given that most of Iowa’s forests comprise mature trees. Additionally, silver maple is a relatively short-lived species that is likely to develop decay as it ages.

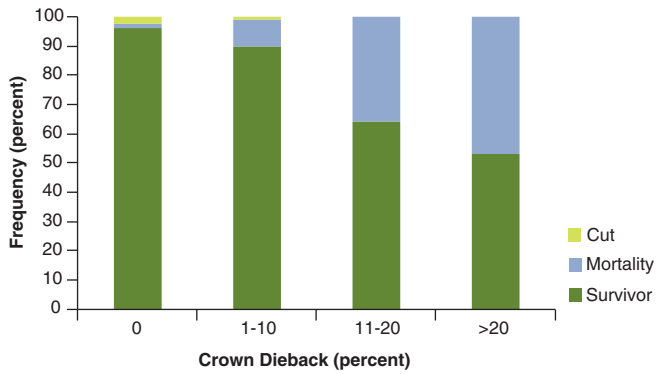


Figure 34.—Crown dieback distribution by tree survivorship for remeasured trees, Iowa, 2004-2008 to 2009-2013.

Table 6.—Percentage of trees with damage, by species, Iowa, 2013

Damage type									Shag-		
	All	American basswood	American elm	Black walnut	Bur oak	Cotton-wood	Hack-berry	Northern red oak	bark hickory	Silver maple	White oak
	----- percent -----										
None	72	66	86	83	80	85	81	81	79	56	86
Animal	5	7	3	4	6	4	2	0	8	17	3
Cankers	2	0	0	1	0	0	1	0	0	3	0
Decay	17	24	4	11	11	9	11	14	9	29	6
Insect damage	2	0	0	0	0	0	2	0	7	2	0
Human activity (e.g., logging, pruning, vandalism)	2	3	2	2	3	0	1	1	2	2	2
Other	2	2	4	1	1	0	1	2	1	4	2
Weather	5	4	4	4	2	3	5	4	2	2	3

Note that columns do not sum to 100 because multiple damages can be recorded on trees.

Insects and Disease Pathogens

Background

Emerald ash borer (EAB), an exotic wood-boring beetle, was detected in the United States in 2002 near Detroit, Michigan. A pest of all North American ash (*Fraxinus* spp.) and white fringetree (*Chionanthus virginicus*), EAB has been present in Iowa since 2010 (Cipollini 2015) (Fig. 35).

Gypsy moth was captured across much of Iowa during the most recent inventory, with the largest concentrations along the northeast border, but it is not currently established in the State. Host tree species were split into preferred and nonpreferred suitability classes based on previously published field and laboratory tests (Liebhold et al. 1995a). Species from suitability class 1 were considered preferred and all others were considered nonpreferred.

Bur oak blight (BOB) is a late-season leaf disease that is increasing in severity on bur oak trees in Iowa. It is caused by the newly described pathogen *Tubakia iowensis*. Symptoms include necrosis of leaf tissue along the veins, which eventually leads to death of the entire leaf starting around late July (Harrington et al. 2012). BOB was found on bur oaks throughout Iowa, but mature trees in upland forests appear to be most at risk of severe symptoms.

What we found

Emerald ash borer.—Iowa has 50.8 million ash trees of at least 1 inch d.b.h. on forest land. Of these, 16.1 million are at least 5 inches d.b.h., accounting for 4.7 percent of trees of all species. Highest densities of ash occur in the northeastern portion of the State (Fig. 35). Although ash growing-stock mortality on timberland was fairly stable from 1990 to 2008, it increased threefold in 2013, reaching 1.5 million cubic feet per year. Most of this mortality was concentrated in northeastern Iowa.

Gypsy moth.—About 51 percent of the live-tree volume in Iowa included species preferred by gypsy moth. The most abundant preferred species in the State were the oaks and black willow. The highest density of host species preferred by gypsy moth occurred in the southeastern forests near the Des Moines River (Fig. 36).

Bur oak blight.—Nearly 98 percent of Iowa's 32 million bur oaks occurred on upland forest land. Sixty-two percent of upland forest bur oaks were in large, sawtimber-sized stands (Fig. 37). There were 10.5 million bur oaks in mature stands with an age of at least 76 years, with 84 percent of those in sawtimber-sized stands. Average annual mortality of bur oaks increased from 214,202 trees per year in the 2008 inventory to 235,855 trees per year in 2013 (Fig. 38). Disease as the cause of death was not recorded in any bur oaks in the 2008 inventory, but in the 2013 inventory the death of an average of 40,557 bur oaks per year was attributed to disease.

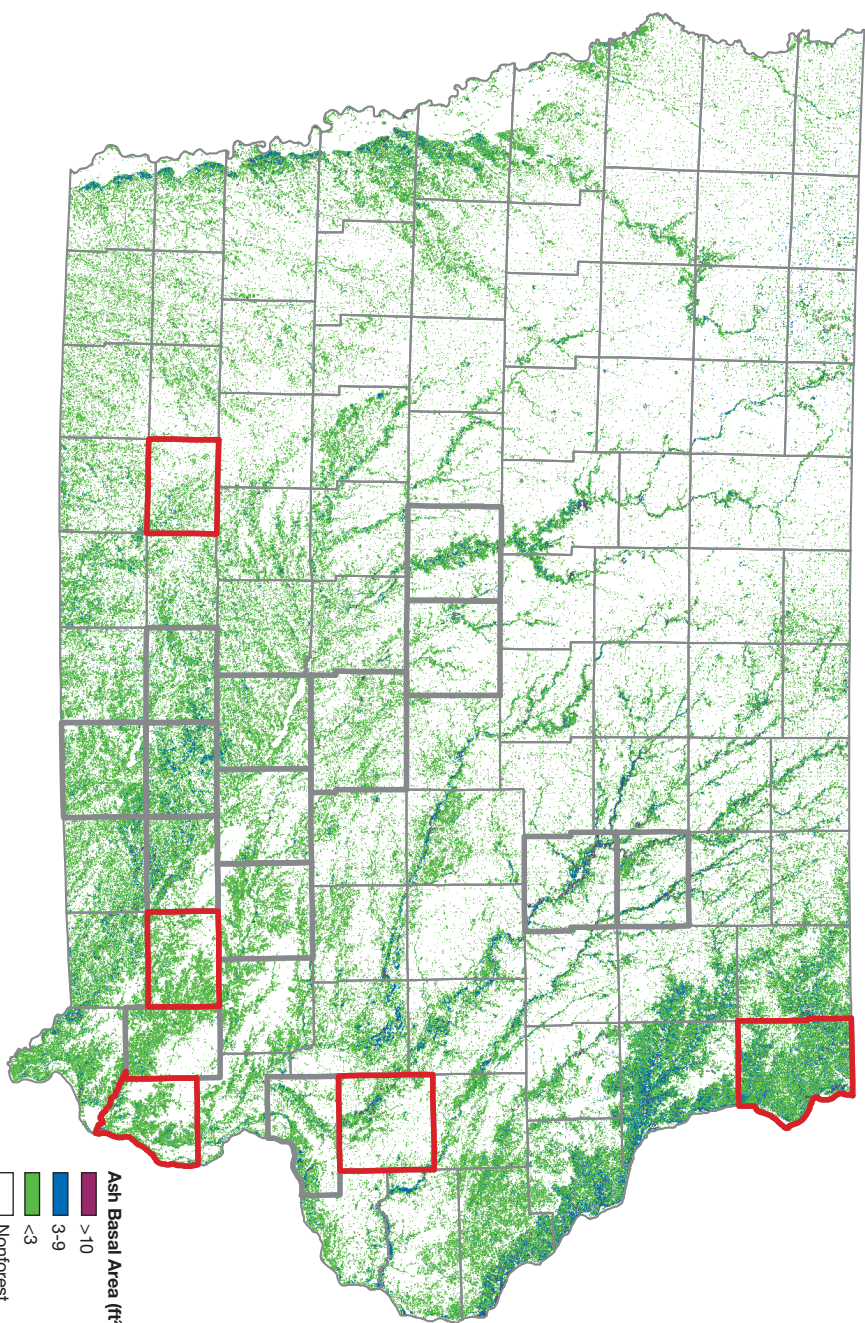
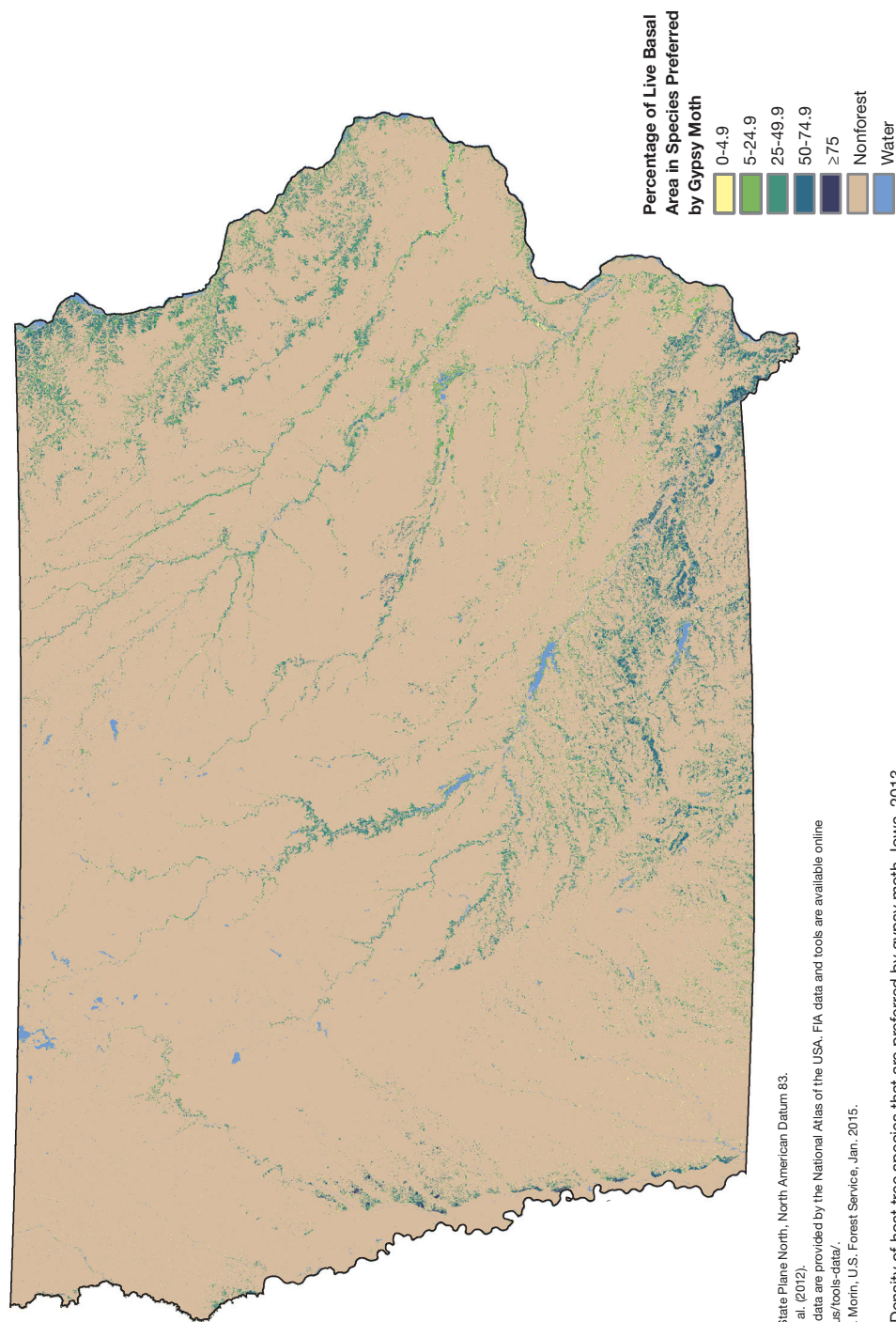


Figure 35. — Ash density on forest land and presence of emerald ash borer, Iowa, 2013.

- Ash Basal Area (ft² / acre)**
- >10
 - 3-9
 - <3
 - Nonforest
 - EAB positive (as of December 2013)
 - EAB positive (as of January 2015)



Projection: Iowa State Plane North, North American Datum 83.
 Source: Wilson et al. (2012).
 Geographic base data are provided by the National Atlas of the USA. FIA data and tools are available online at www.fia.fs.fed.us/tools-data/.
 Cartography: R.S. Morin, U.S. Forest Service, Jan. 2015.

Figure 36. — Density of host tree species that are preferred by gypsy moth, Iowa, 2013.

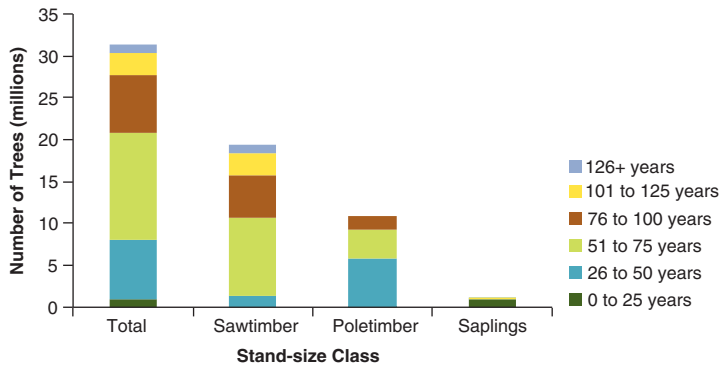


Figure 37.—Number of bur oak trees on uplands by stand-size class and stand-age class, Iowa, 2013.

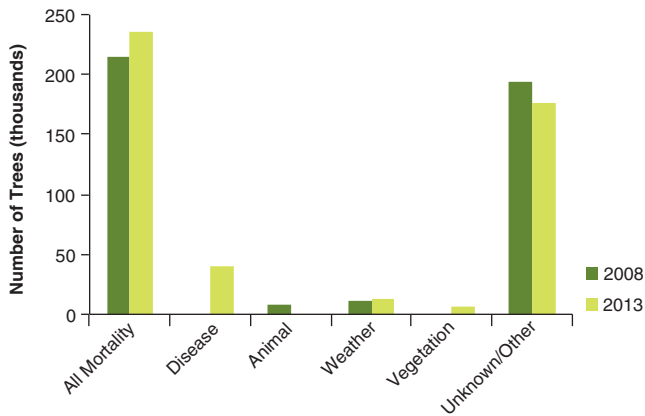


Figure 38.—Average annual mortality of bur oak trees by cause of death, Iowa, 2008 and 2013.

What this means

Emerald ash borer.—Because EAB is likely to be the largest contributor to ash mortality, the continued spread of EAB could have a considerable impact on ash health and the future composition of Iowa’s forests.

Gypsy moth.—As gypsy moth continues to spread west across the United States, quantification of the amount of the forest resource that is preferred by this insect can help land managers prepare for future outbreaks.

Bur oak blight.—The increase in bur oak mortality and better identification of disease as the cause of death may indicate a potential rise of BOB in Iowa. As climate change potentially creates conditions that may favor BOB, such as increased spring precipitation, Iowa’s valuable bur oak resource may be under further pressure from BOB.

Down Woody Materials

Background

Down woody materials, in the various forms of fallen trees and shed branches, fill a critical ecological niche in Iowa’s forests. Down woody materials provide valuable wildlife habitat, stand structural diversity, and a store of carbon and biomass; they also contribute to forest fire hazards via surface woody fuels.

What we found

The total carbon stored in down woody materials (fine and coarse woody debris) on Iowa’s forest land exceeded 8 million tons (Fig. 39). Downed woody debris carbon was normally distributed by stand age class, meaning that moderate-aged stands (41-80 years) had the highest total carbon (about 2.3 million tons), with less carbon in both younger and older ages classes (Fig. 39). More than 18.5 million tons of downed dead wood biomass occur within Iowa’s forests, dominated by coarse woody debris at 69 percent; the remainder is fine woody debris (31 percent), with almost no dead wood biomass in residue piles. The total volume of coarse woody debris was highest in the private ownership category at roughly 1 billion cubic feet across Iowa’s forests (Fig. 40). State and local forests had the second largest total of coarse woody debris volume (about 86 million cubic feet).

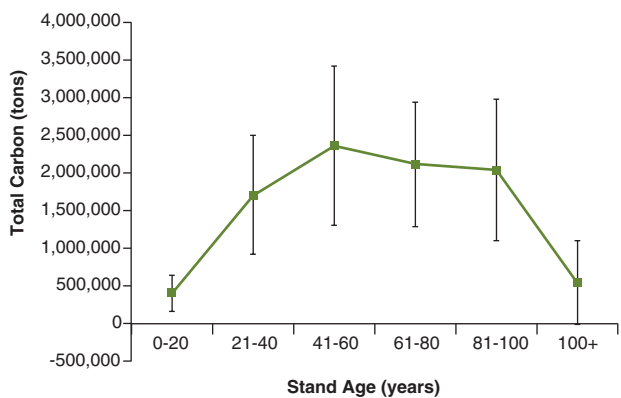


Figure 39.—Total carbon in down woody materials (fine and coarse woody debris and piles) by stand-age class on forest land, and associated sampling error, Iowa, 2009-2013.

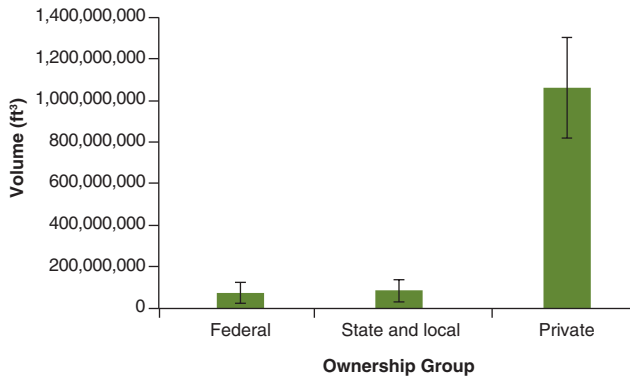


Figure 40. — Total volume of coarse woody debris on forest land by ownership group, and associated sampling error, Iowa, 2009-2013.

What this means

Given the relatively moist temperate forests across Iowa, only in times of drought would the biomass of down woody materials be considered a fire hazard. Although the carbon stocks of down woody materials are small compared to those of soils and standing live biomass across Iowa, down woody materials are still a critical component of the carbon cycle as a transitory stage between live biomass and other detrital pools such as the litter. Beyond transition of dead wood carbon to other pools, there is a potential for a reduction in these stocks due to increased rates of decay if future temperature and precipitation patterns change as projected (Russell et al. 2014a, 2014b). The loss of dead wood carbon stocks could indicate the reduction of other pools in the future. In contrast with southeastern states, where there is more widespread industrial management of forests (Woodall et al. 2013), no dead wood piles were sampled in this first down woody materials inventory of Iowa's forests. Given that the vast majority of coarse woody debris volume was estimated to be in private ownership, it is the management of Iowa's private forests that may affect future contributions from down woody materials to statewide forest carbon stocks and wildlife habitat (i.e., stand structure). Overall, because fuel loadings are estimated to not be exceedingly high across Iowa, the numerous ecosystem services provided by down woody materials may outweigh possible fire dangers.

Nonnative Invasive Plants

Background

Invasive plant species (IPS) are both native and nonnative species that can cause negative ecological effects. These species can quickly invade forests, changing light, nutrient, and water availability. IPS can form dense monocultures which not only reduce regeneration but also affect wildlife habitat quantity and quality by altering forest structure and forage availability. Despite some beneficial uses of these invaders, such as culinary and medicinal purposes and soil contaminant extraction (reed canarygrass; Kurtz 2013), the negative effects are worrisome. Each year inspection, management, and mitigation of IPS cost billions of dollars. To aid in monitoring these species, FIA assessed the presence of 43 IPS and one undifferentiated genus (nonnative bush honeysuckles) on 107 P2 invasive plots in Iowa from 2009 through 2013. Because field crews code nonnative bush honeysuckles sometimes at the genus level and other times at the species level, this report lumps all of the nonnative bush honeysuckles into one category, reducing the number of species monitored to 40.

What we found

Of the 40 invasive species monitored (Table 7), 15 were observed in Iowa (Table 8). Scientific names for nonnative invasive plants are listed in Table 7. Multiflora rose was the most commonly observed species (66 plots; 61.7 percent, Fig. 41). It was most common in the south-central and eastern regions of Iowa (Fig. 42). Reed canarygrass (48 plots), nonnative bush honeysuckles (39 plots), and garlic mustard (21 plots) were also found on many plots. The other 11 species were found on less than 9 percent of plots. One or more IPS were found on 94.4 percent of the monitored plots in Iowa. On plots with invasive plants, the percentage of a plot that was forested was lower than for those plots without invasive plants (71.4 percent versus 91.3 percent, respectively).



Figure 41.—Multiflora rose. Photo by James H. Miller, U.S. Forest Service, Bugwood.org.

Table 7.—List of 39 invasive plant species and one undifferentiated genus monitored by the Northern Research Station on Forest Inventory and Analysis P2 invasive plots, 2007-2013

Tree Species	Vine Species
Ailanthus (<i>Ailanthus altissima</i>)	English ivy (<i>Hedera helix</i>)
Black locust (<i>Robinia pseudoacacia</i>)	Japanese honeysuckle (<i>Lonicera japonica</i>)
Chinaberry (<i>Melia azedarach</i>)	Oriental bittersweet (<i>Celastrus orbiculatus</i>)
Chinese tallowtree (<i>Triadica sebifera</i>)	
Norway maple (<i>Acer platanoides</i>)	Herbaceous Species
Russian olive (<i>Elaeagnus angustifolia</i>)	Black swallow-wort (<i>Cynanchum louiseae</i>)
Princesstree (<i>Paulownia tomentosa</i>)	Bull thistle (<i>Cirsium vulgare</i>)
Punktree (<i>Melaleuca quinquenervia</i>)	Canada thistle (<i>Cirsium arvense</i>)
Saltcedar (<i>Tamarix ramosissima</i>)	Creeping jenny (<i>Lysimachia nummularia</i>)
Siberian elm (<i>Ulmus pumila</i>)	Dames rocket (<i>Hesperis matronalis</i>)
Silktree (<i>Albizia julibrissin</i>)	European swallow-wort (<i>Cynanchum rossicum</i>)
	Garlic mustard (<i>Alliaria petiolata</i>)
Shrub Species	Giant knotweed (<i>Polygonum sachalinense</i>)
Autumn olive (<i>Elaeagnus umbellata</i>)	Japanese knotweed (<i>Polygonum cuspidatum</i>)
Common barberry (<i>Berberis vulgaris</i>)	Leafy spurge (<i>Euphorbia esula</i>)
Common buckthorn (<i>Rhamnus cathartica</i>)	Bohemian knotweed (<i>Polygonum xbohemicum</i>)
European cranberrybush (<i>Viburnum opulus</i>)	Purple loosestrife (<i>Lythrum salicaria</i>)
European privet (<i>Ligustrum vulgare</i>)	Spotted knapweed (<i>Centaurea stoebe</i> ssp. <i>micranthos</i>)
Glossy buckthorn (<i>Frangula alnus</i>)	
Japanese barberry (<i>Berberis thunbergii</i>)	Grass Species
Japanese meadowsweet (<i>Spiraea japonica</i>)	Common reed (<i>Phragmites australis</i>)
Multiflora rose (<i>Rosa multiflora</i>)	Nepalese browntop (<i>Microstegium vimineum</i>)
Nonnative bush honeysuckles (<i>Lonicera</i> spp.)	Reed canarygrass (<i>Phalaris arundinacea</i>)

Table 8.—List of 14 invasive plant species and one undifferentiated genus detected on Iowa plots, 2009-2013

Name	Observances	Percentage of plots
Multiflora rose	66	61.7
Reed canarygrass	48	44.9
Nonnative bush honeysuckles	39	36.4
Garlic mustard	21	19.6
Autumn olive	9	8.4
Bull thistle	8	7.5
Common buckthorn	8	7.5
Black locust	7	6.5
Siberian elm	6	5.6
Japanese barberry	4	3.7
Canada thistle	2	1.9
Creeping jenny	2	1.9
Dames rocket	1	0.9
Japanese knotweed	1	0.9
Oriental bittersweet	1	0.9

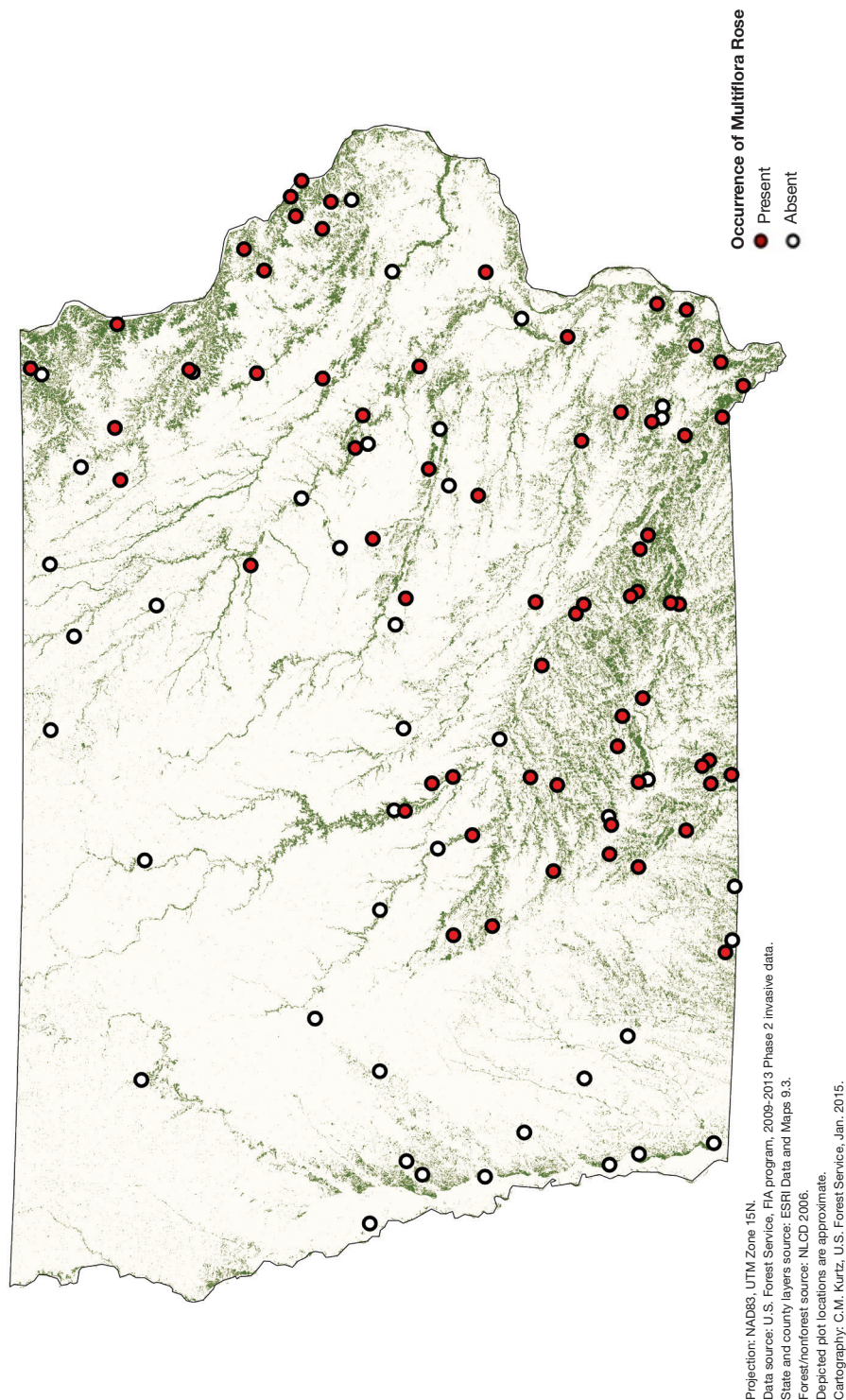


Figure 42.— Approximate location of P2 invasive plots showing the presence and absence of multiflora rose, the most commonly occurring invasive plant species of those monitored in this region, 2009-2013.

Changes in Iowa from 2007-2008 to 2009-2013

In the 2007-2008 survey 15 IPS were observed in Iowa (Nelson et al. 2011), the same number as in the 2009-2013 survey. However, there were actually more IPS observed in this survey because nonnative bush honeysuckles were combined into one group. Creeping jenny and Japanese knotweed are two IPS that were not observed last time but were found in this inventory. These two invasive plants are commonly used for landscaping. Japanese knotweed is of particular concern as it is very difficult to control, can penetrate pavement, and poses a fire hazard (Kurtz 2013). As in the 2007-2008 survey, the two most commonly recorded species remained the same, multiflora rose and reed canarygrass, though both occurred on around 10 percent more plots in this inventory. This increase in presence was not found for all the invasive species monitored. Species such as autumn olive, common buckthorn, Japanese barberry, dames rocket, and Oriental bittersweet occurred on a lower percentage of plots in this inventory.

What this means

The presence of IPS within Iowa's rich forests is a concern and it is important that these species are monitored over time to ensure that managers and the public are aware of their occurrence and spread. Further investigation of the inventory data may help to reveal influential site and regional trends. Invasive plants are good competitors and are able to alter forested ecosystems by displacing native species and affecting the fauna that depend upon them. Several characteristics contribute to their success, such as prolific seed production, ability to propagate vegetatively, rapid growth rate, and ability to survive in harsh conditions. Among the many factors that exacerbate invasion of forests by IPS are ungulates (e.g., cattle grazing), timber harvesting, development, and fragmentation (plots on a forest/nonforest edge were more likely to have IPS). When forests are invaded, IPS negatively affect the carbon budget by reducing future tree cover. Furthermore, these species can have costly economic implications through diminished timber yield and aesthetic beauty.

Nonforest Trees

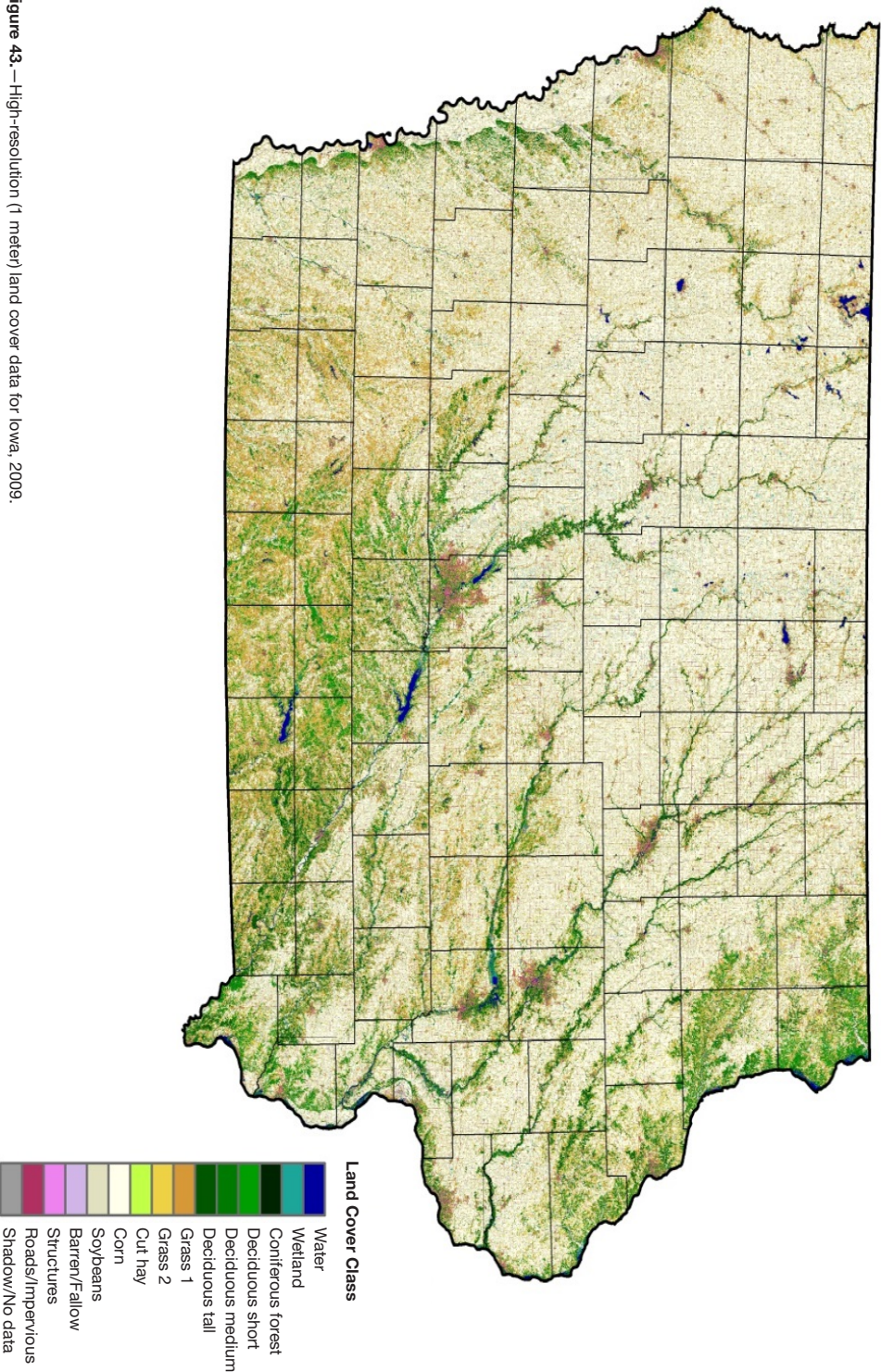
Background

Areas of tree cover must be at least 1 acre in size and 120 feet wide to meet FIA's definition of forest land. Some of the tree cover in Iowa, however, is configured in a way (e.g., narrow linear strips) that does not meet these requirements. Despite their small or narrow patch sizes, these groupings of trees are a critical resource and offer a wide range of benefits, such as preventing erosion, serving as riparian buffers, providing wildlife habitat, sequestering carbon, and protecting structures and livestock from harsh weather. Recently, natural resource agencies have noted a deficiency of available information on this important nonforest tree (NFT) resource.

The lack of information is a concern, but obtaining such data is challenging. Remote sensing-based land cover geospatial datasets are often produced at spatial resolutions that are too coarse to identify narrow tree plantings or individual tree crowns.

However, digital aerial imagery, such as that from the National Agriculture Imagery Program (NAIP) is acquired at a spatial resolution sufficient to identify such features. The Iowa Department of Natural Resources used multiple dates of NAIP imagery and elevation data derived from light detection and ranging (LiDAR) to create a 15-class high-resolution (i.e., 1 meter or 3.28 feet) land cover dataset (HRLCD) for the entire State with an effective date of 2009 (Fig. 43). We compared county- and state-level areas of tree cover from the HRLCD to county- and state-level estimates of forest land area reported by FIA in order to gain an understanding of the additional NFT resource in Iowa.

Figure 43. —High-resolution (1 meter) land cover data for Iowa, 2009.



What we found

The high-resolution land cover data were available for all 99 counties in Iowa. The HRLCD identified about 4 million acres of tree cover whereas the FIA estimate of forest land for the State was just under 3 million acres. The HRLCD estimate of tree cover was larger for 83 counties compared to the FIA estimates. A county-by-county analysis found that the largest difference between the HRLCD and FIA estimates occurred in Dubuque County, where the HRLCD estimate was nearly 49,000 acres larger; the smallest difference in estimates was for Guthrie County with a mere 63 acres of difference. On average, the HRLCD per-county estimate of tree cover was about 9,900 acres more than the FIA estimate of forest land area. Figure 44 shows the relationship between county-level estimates of tree cover obtained from the HRLCD versus estimates of forest land area from FIA. Even when the FIA estimate reported no forest land area for a county, the HRLCD identified some area of tree cover for that county. There were 16 counties where the FIA estimate of forest land was higher than the HRLCD estimate of tree cover.

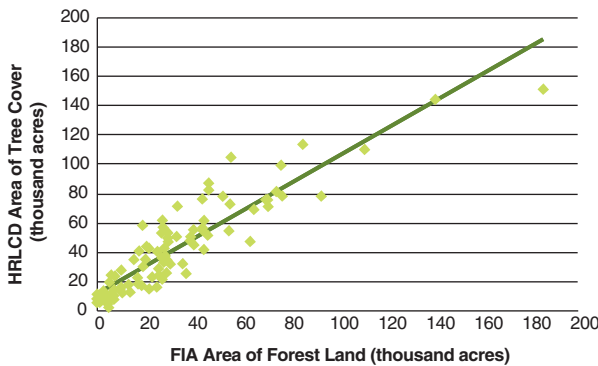


Figure 44.—County-level estimates of Forest Inventory and Analysis (FIA) forest land area (2013) versus estimates of tree-covered areas obtained from high-resolution land cover data (HRLCD) for Iowa, 2009.

What this means

Iowa contains a large amount of treed lands that do not meet FIA’s definition of forest land but that are nonetheless a significant tree resource. It is important that these areas continue to be monitored and managed because they are vital for protecting soil, wildlife, domestic animals, homes, roads, water sources, and recreational areas. The results obtained from remote sensing-based procedures can provide useful information for the careful management of the NFT resource as well as the ecosystem services these trees provide. One important advantage of high-resolution datasets of tree cover is that not only do we know more about their total extent, we are also provided with

detailed locational information for more comprehensive monitoring of changes to the overall tree resources in the State. Changes in land use practices that affect nonforest windbreaks and other narrow linear tree features could go unnoticed if using traditional inventory definitions and methods. A remote sensing-based monitoring program provides enhanced monitoring of such resources. Note that FIA- and HRLCD-based estimates may also differ due to land use versus land cover definitions. Recently harvested forest stands in early stages of regeneration are still labeled as forest by FIA, but probably would show no tree cover in the HRLCD. Tree cover in a context of nonforest use would be labeled as nonforest in FIA, but would still be included within HRLCD. Forest loss (diversion) following 2009 would not be detected by HRLCD, but would be identified in FIA data. See additional discussion of land use and land cover in the sections on Land-Use Change and Fragmentation and Urbanization of Forest Land on pp. 14 and 40, respectively.

Regeneration Status

Background

The composition and abundance of tree seedlings (Fig. 45) drive the character of forest ecosystems in the early years of stand development. Benefits of forest in the early phases of development are described in the Forest Successional Stage section on p. 77. Young forests set the stage for future composition and structure, and hence, the viability and sustainability of timber and ecosystem services provided (e.g., riparian forest habitat, carbon sequestration, and scenic beauty). Nelson et al. (2011) recommended monitoring regeneration of Iowa's forests because of the economic importance of larger-diameter species, which are aging, undergoing unprecedented mortality levels, and will eventually need replacement. These species are the cornerstone of Iowa's wood products and manufacturing industry, which contributes nearly



Figure 45.—Bur oak seedling. Photo by Carl Strang, courtesy of the Forest Preserve District of Du Page County, Illinois.

\$4 billion in annual sales, \$900 million in annual payroll, and more than \$25 million in annual timber sales to private woodland owners (Iowa Department of Natural Resources 2009).

Forest systems of Iowa face numerous regeneration stressors, such as invasive plants, insects and diseases, herbivory, and climate change. As stands that make up these systems mature and undergo stand replacement disturbances, it is imperative to know the condition of the regeneration component. Although planting or seeding are options in some stands, the region is dominated by forest systems that regenerate naturally. In most situations, establishing desirable reproduction is the key to replacing stands in need with high-canopy species that meet managers' objectives. Tending of young stands to control composition and stocking levels is also a very important consideration (Smith 1997). Regeneration data are critically important for understanding and projecting future forest character, which ultimately determines sustainability of the full suite of forest values available from Iowa's forests. To address the need for more detailed information on regeneration, the FIA program of the Northern Research Station (NRS) has added measurement protocols collected on a subset of NRS-FIA sample plots measured during the growing season (McWilliams et al. 2015). The procedures measure all established tree seedlings less than 1-inch d.b.h. by length class and include a browse impact assessment for the area surrounding the sample location. These Regeneration Indicator data improve NRS-FIA's ability to evaluate this important aspect of forest health and sustainability.

What we found

The results in this report are based on 26 sample plots measured in 2012 and 2013. Results of the browse impact assessment show that most of the samples (75 percent) had either medium or low levels of browse of understory plants (Fig. 46). The other one-quarter of the samples had high or very high browse impact. Examination of browse impact across the State does not reveal any distinct pattern other than small localized impacts (Fig. 47). It should be noted that there are relatively few samples to evaluate regional patterns.

The total number of seedlings was estimated at 20.1 billion, or an average of 7,700 seedlings per acre of forest land. About 75 percent of the seedlings are less than 1 foot tall, 22 percent are 1.0 to 4.9 feet, and 3 percent are 5.0 feet and taller (Fig. 48). Nearly 54 percent of all samples had 0-5,000 seedlings per acre, and over one-quarter had more than 10,000 seedlings per acre (Fig. 49). Overall seedling abundance exhibits no particular geographical pattern across Iowa (Fig. 50). Hackberry, silver maple, and white

ash make up two-thirds of the estimated total number of seedlings (Fig. 51A), and each of these species has more than 1,000 seedlings per acre (Fig. 51B), on average. Other species with at least 2 percent of the seedling sample are chokecherry (7 percent), an understory species; eastern hophornbeam (7 percent), slippery elm (3 percent), and mulberry (either red or white) (2 percent), typically mid-story species; and green ash (2 percent) and bitternut hickory (2 percent), capable of reaching high canopy.

The Regeneration Indicator data collected so far for tree seedlings do not warrant detailed analysis by species because of the relatively small number of samples and high sampling errors. As an alternative, the status of saplings and adult trees provides insight into regeneration trends. Figure 52 depicts the number of live trees by diameter class for eight species of importance in Iowa. Both positive and negative findings are apparent. Species with decreasing numbers of saplings since the 2003 inventory will eventually have less biomass and volume as this reduced pool of small trees reaches larger, more merchantable size classes. Bur oak had level numbers for the 2-inch diameter class and decreasing numbers for the 4- and 6-inch classes. Shagbark hickory had a decrease of almost one-third in the 2-inch class, but a 27 percent decrease in the 4-inch class, and little change in larger diameter classes. Gains in regeneration are suggested by increases in the number of saplings for cottonwood, black walnut, and northern red oak. Findings were mixed and bear watching for silver maple, white oak, and black oak. Black ash had a 16 percent increase in 2-inch trees, but it also had decreases in the 4- to 10-inch classes. Eastern redcedar increased across all small and large diameters, thus continuing trends discussed by Schmidt and Leatherberry (1995).

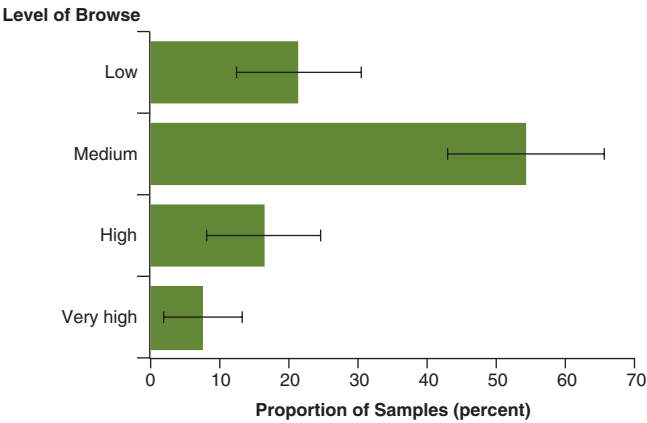


Figure 46.—Percentage of forested P2+ samples on forest land by browse impact, and associated sampling error, Iowa, 2012-2013.

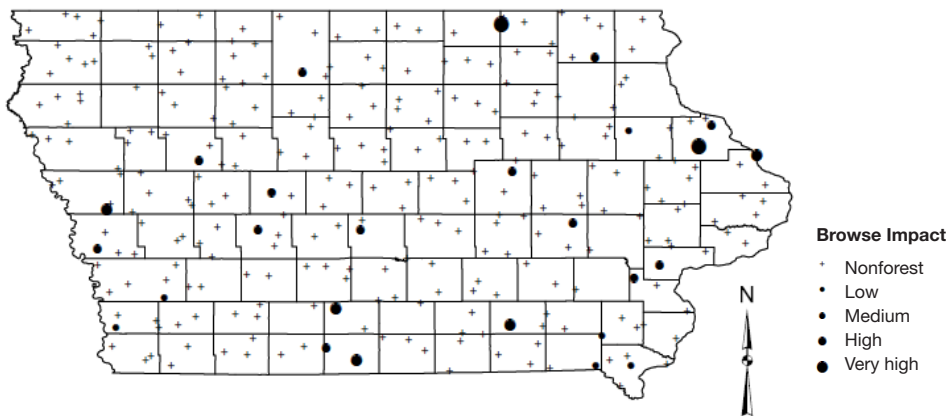


Figure 47.—Distribution of forested P2+ samples on forest land by browse impact, Iowa, 2012-2013. (Depicted plot locations are approximate.)

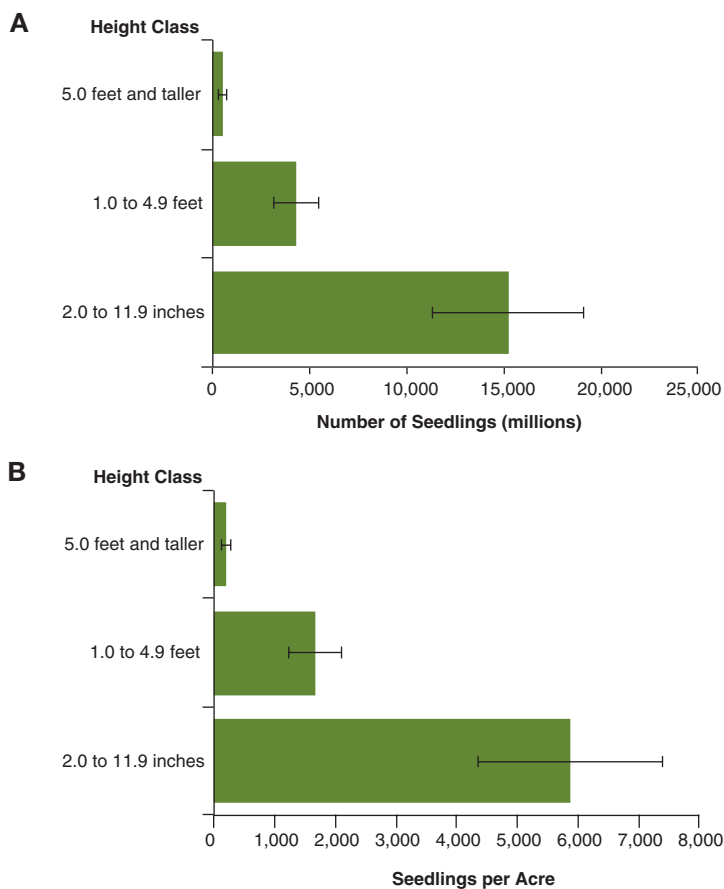


Figure 48.—Average number of seedlings (A) and seedlings per acre (B) on forest land by height class, and associated sampling error, Iowa, 2012-2013. Error bars represent a 68 percent confidence interval around each estimate.

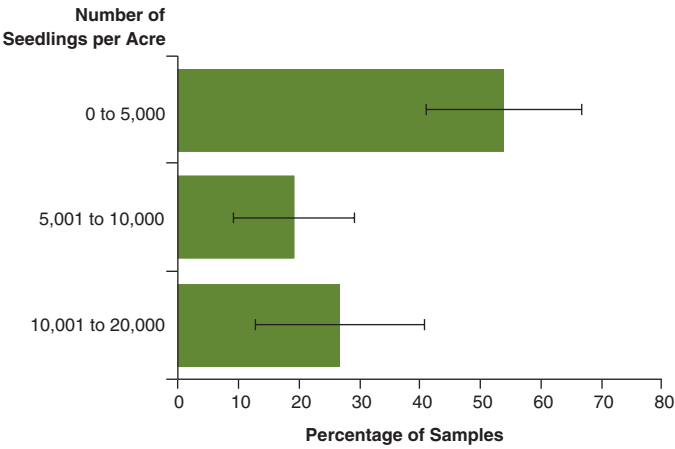


Figure 49.—Percentage of forested P2+ samples on forest land by class of seedlings per acre, and associated sampling error, Iowa, 2012-2013.

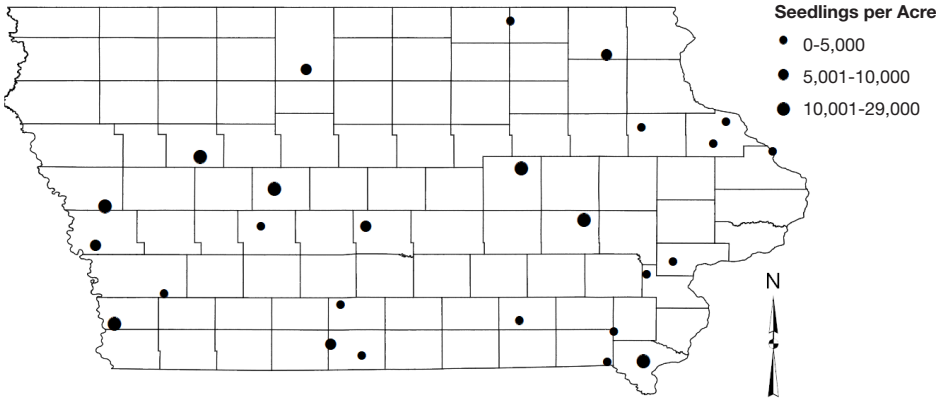


Figure 50.—Distribution of forested P2+ samples on forest land by class of seedlings per acre, Iowa, 2012-2013. (Depicted plot locations are approximate.)

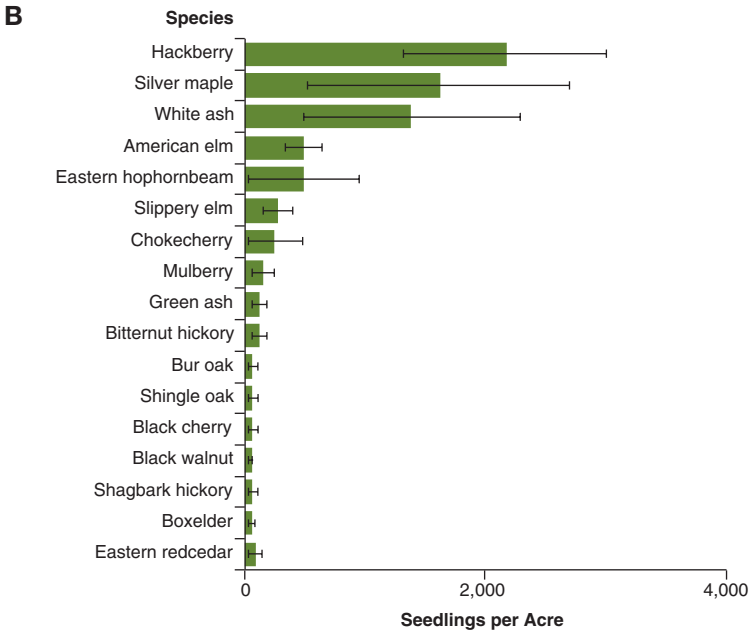
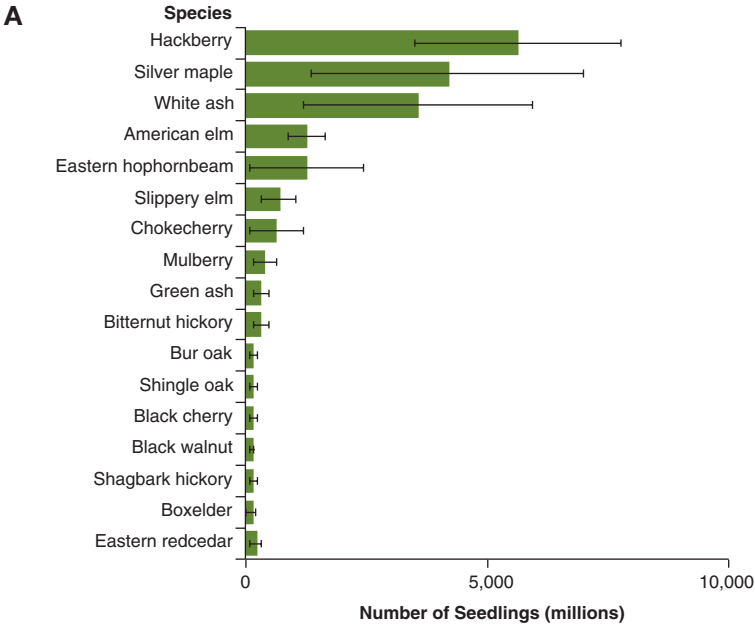


Figure 51.—Number of seedlings (A) and average number of seedlings per acre (B) on forest land by species for species with at least 1 percent of the total number of seedlings, and associated sampling error, Iowa, 2012-2013. Mulberry includes both white and red species.

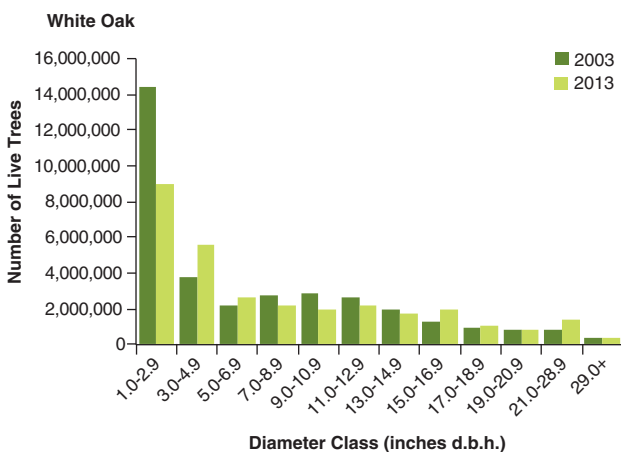
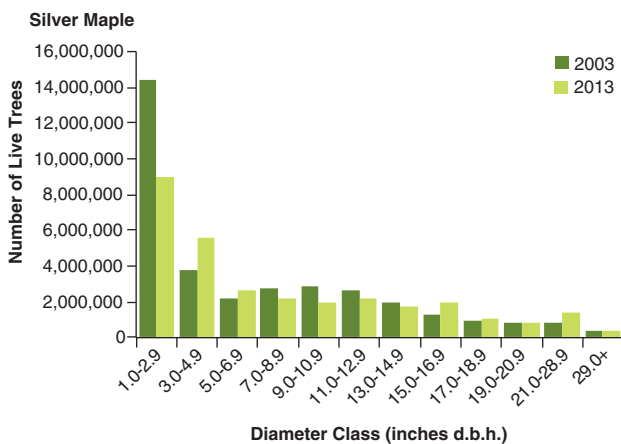
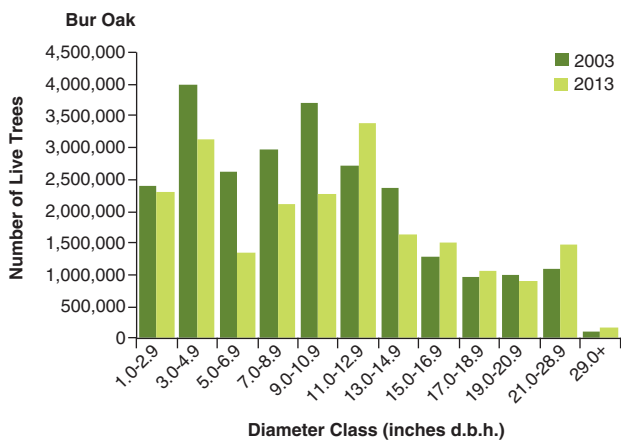


Figure 52.—Number of live trees on forest land, by diameter class, Iowa, 2003 and 2013, for eight species. (Continued on next page)

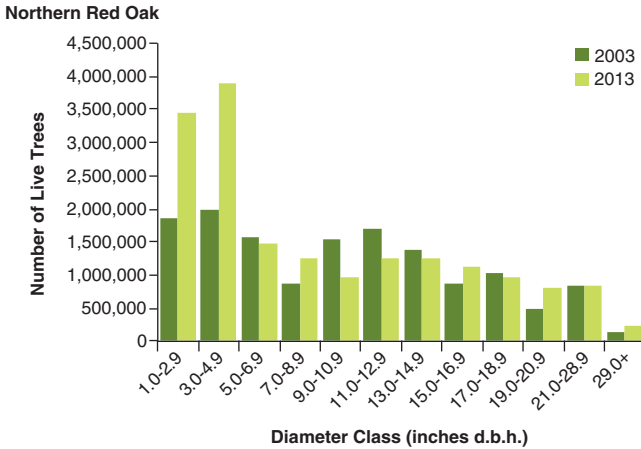
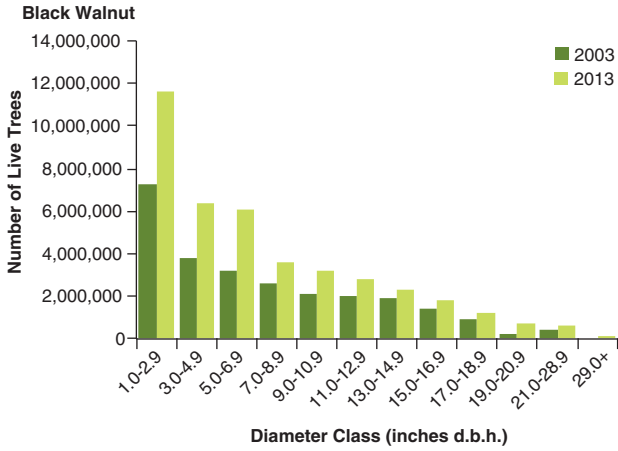
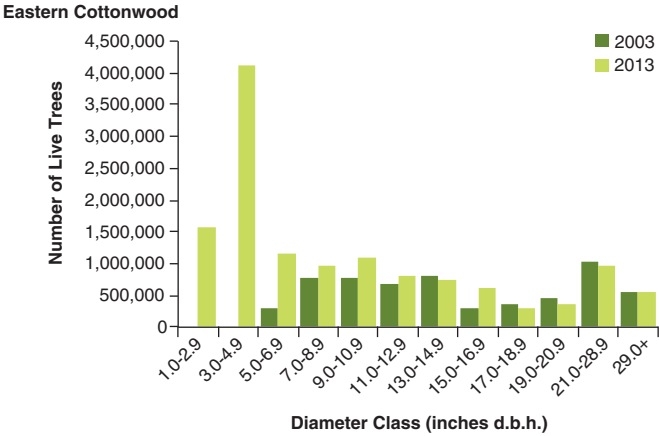


Figure 52. (Continued)—Number of live trees on forest land, by diameter class, Iowa, 2003 and 2013, for eight species. (Continued on next page)

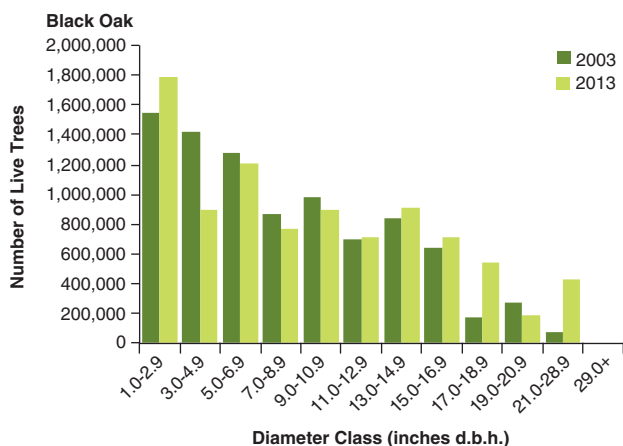
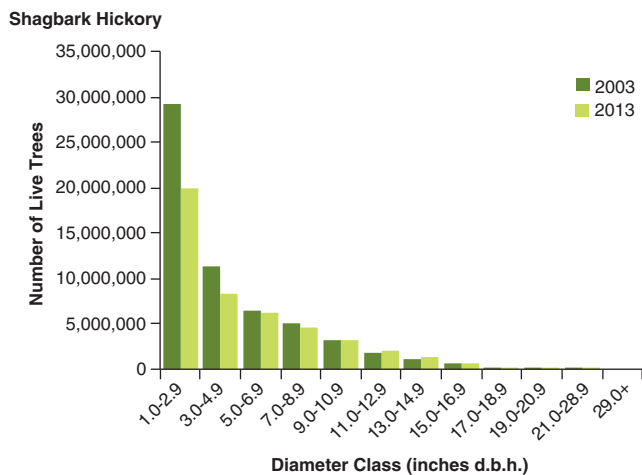


Figure 52. (Continued)—Number of live trees on forest land, by diameter class, Iowa, 2003 and 2013, for eight species.

What this means

Early successional young forest habitat is critical for providing unique plant biota and landscape heterogeneity (Greenberg et al. 2011). The quality of Iowa’s young forest depends directly on the condition of the regeneration component. Regeneration is also the principal determinant of future benefits from mature forests, such as timber, carbon sequestration, and water quality. As Iowa’s forest stands continue to age, young forest is becoming increasingly rare. Older, more mature stands are dominating the forest landscape. Since 1990, the area of young forest (0 to 20 years old) decreased from 13 percent of the total forest area to only 5 percent. Young oak-hickory stands now make up less than 3 percent of the oak/hickory forest-type group. This is

important because the oak/hickory forest-type group accounts for about two-thirds of Iowa's forest and is critical for timber and for providing hard mast for wildlife.

The State's maturing forest faces a wide variety of stress factors other than aging that work together to make regeneration a major issue for forest managers and policy-makers. Conversion to nonforest land uses, forest fragmentation, and invasion by nonnative invasive plants, insects, and diseases are important stress factors (Reeder 2012), particularly on private land, which makes up 9 out of 10 acres of the State's forest land. Some of the most dominant and valuable species of older forests, such as the oaks, ashes, black walnut, and maples, are associated with the major risk factors described by the Iowa Department of Natural Resources (2013). The most significant emerging threats listed are gypsy moth, emerald ash borer, bur oak blight (*Tubakia iowensis*), thousand cankers disease, and Asian longhorned beetle. See Insects and Disease Pathogens section on p. 51 for additional discussion of these pathogens.

Browsing of tree seedlings by white-tailed deer (*Odocoileus virginianus*) is also a significant stressor. Although most of the browse impact was found to be at a medium level, about one-quarter of the samples had high or very high impact and browsing is a serious threat to regeneration in some local areas (Iowa Department of Natural Resources 2009). Eventually, most forest stands will undergo either anthropogenic or natural stand replacement events, such as harvest or mortality, and require regeneration to establish new young forest. Forest regeneration will be the key to successful establishment of new young forests.

Information from the Regeneration Indicator offers insight into prospective trends for species of particular interest to Iowans. Iowa's State Tree is the oak, of which 12 species are native to the State. Bur oak is found across Iowa and is important not only for timber, but also for wildlife. Bur oak regeneration bears watching because of decreased numbers of stems across the smaller diameter classes. Decreased number of smaller stems is also a concern for shagbark hickory. Both bur oak and shagbark hickory provide spring, summer, and fall roosting for Indiana bats (*Myotis sodalis*) when in proximity to hibernacula; limited regeneration could reduce the extent of future bat habitat (Menzel et al. 2001). See also Forest Wildlife Habitat section on p. 74.

The future of ash species is a concern due to the emerald ash borer and in the case of black ash, due to a lack of regeneration (see also Insects and Disease Pathogens section on p. 51). Decreases in smaller black ash stems are likely to have a negative impact on the availability of future source material, which is used by Native Americans for hand-woven baskets. Positive trends in cottonwood regeneration should offset some of the loss of ash species in riparian forests due to emerald ash

borer, although potential impacts to, or shifts in, wildlife species composition as a result of forest composition change are unknown.

Oak regeneration problems and difficulties are a well-known issue in the Midwest (Holt and Fischer 1979). Positive trends in the number of small northern red oak trees are encouraging; however, it appears that white oak regeneration needs to be watched due to a large decrease in 2-inch saplings. Technically, black walnut stands are included in the FIA definition of the oak/hickory forest-type group. Positive findings for walnut regeneration foretell increases in this valuable resource.

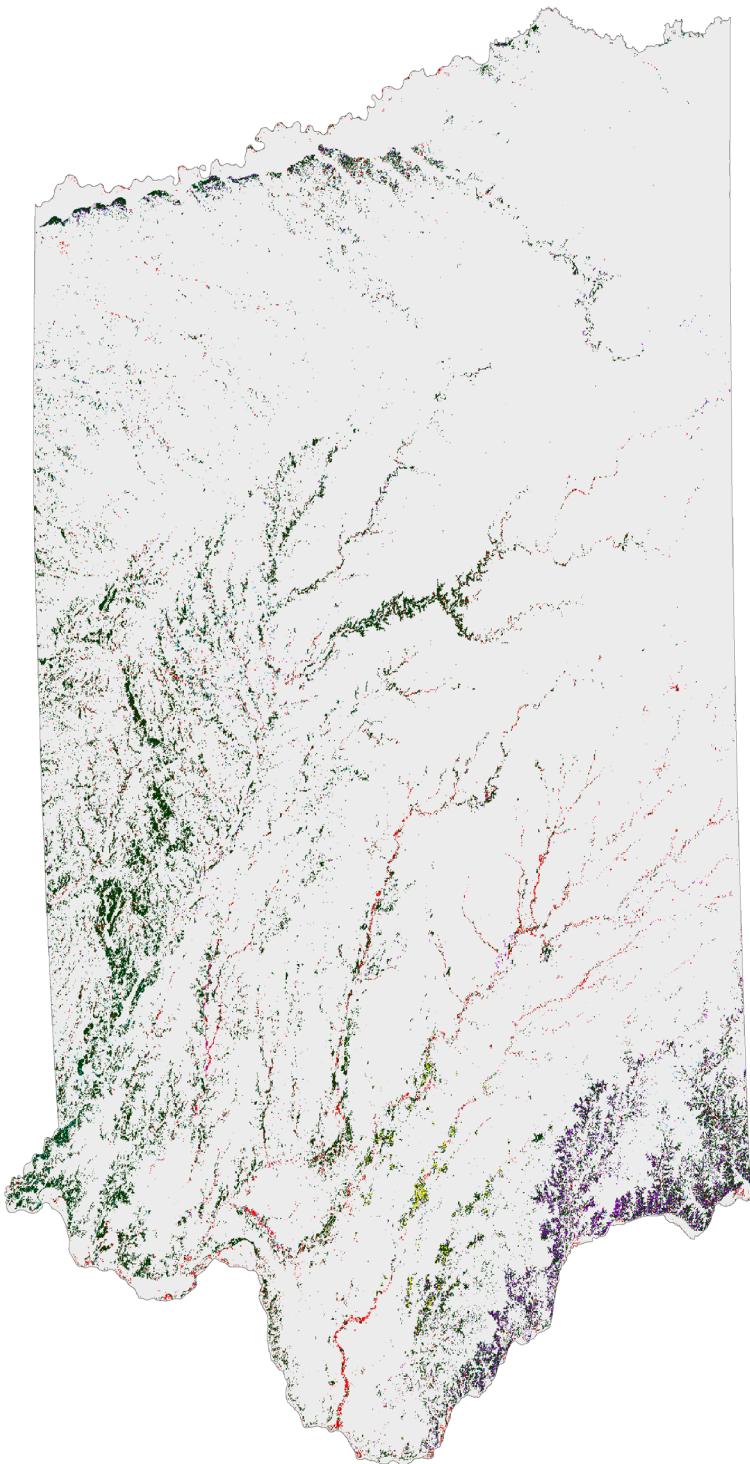
The results presented here reflect only two of the seven panels of measurements that will eventually constitute the first full baseline dataset for the Regeneration Indicator. Barring any extension of the inventory cycle length, the next 5-year inventory report for Iowa (for the year 2018) will coincide with the completion of the baseline dataset. This will fill in crucial data gaps and allow more detailed analyses by improving the level of statistical confidence in the estimates (in other words, narrower confidence intervals). The dataset will also facilitate research to evaluate plot-level regeneration adequacy for the major forest-type groups and a more complete understanding of future trends in composition, structure, and health of Iowa's forests. Sound forest management, policy, and planning for regeneration will ensure a sustainable future for Iowa's treasured forest resources for the rest of this century.

Forest Wildlife Habitat

Forests, woodlands, and savannas provide habitats for many species of Iowa birds (154), mammals (42), and amphibians and reptiles (42) (NatureServe 2011). Different forest types at different structural stages provide natural communities (habitats) at a “coarse filter” scale of conservation (Fig. 53). Rare, imperiled, or wide-ranging wildlife species may not be fully served at this scale, so a “fine filter” approach is used to identify species-specific conservation needs. Representing an intermediate or “mesofilter” scale of conservation are specific habitat features (e.g., snags, riparian forest strips), which may serve particular habitat requirements for multiple species (Hunter 2005). This report characterizes habitats at the coarse-filter scale (forest age and size) and mesofilter scale (standing dead trees). We do not estimate habitat abundance for specific wildlife species.

Like all states, Iowa has developed a state wildlife action plan (SWAP). The Iowa Wildlife Action Plan (IWAP) (Iowa Department of Natural Resources [2005]; revised in May 2006 and August 2012 [Reeder 2012]) identifies species of greatest conservation need (SGCN). Of the broad habitat categories in Iowa, wooded lands (forests, wet forest/woodlands, woodland, and shrubland habitats) have the greatest number of SGCN: 73 birds, 22 mammals, 23 reptiles and amphibians, 22 butterflies, 8 land snails, and 1 dragonfly/damselfly. According to this plan, Iowa timber stands are maturing, providing habitat for wildlife species that depend upon late successional stages. Shade-tolerant tree species like sugar maple are overtaking some oak-dominated stands. Previously grazed pasture is reverting to early successional forest, but often because of invasive species like eastern redcedar. Degraded habitats and issues of landscape pattern—fragmentation and habitat block size—affect the suitability or productivity of habitats. One of the mesofilter conservation issues associated with forest habitats is the presence and abundance of snags and nest cavities. The IWAP also lists climate change as a high threat to forest-associated bird SGCN. We report on the condition and trends in forest attributes of forest age and size, and the quantity and distribution of standing dead trees. We project potential changes in tree species distributions that may influence future bird species distributions. Forest fragmentation, which is listed as a high threat to all taxa of Iowa's SGCN, is addressed in the Fragmentation and Urbanization of Forest Land section on p. 40 of this report. Impacts of browsing (primarily by white-tailed deer) and regeneration are discussed in the Regeneration Status section on p. 64 of this report.

Figure 53. — Distribution of forest-type groups on forest land, Iowa, 2009. Data source: Wilson et al. (2012).



Forest Successional Stage

Background

Some species of wildlife depend upon early successional forests, which contain younger, smaller trees. Others require older, larger trees with complex canopy structure. Some species prefer interior forests; other species inhabit the ecotone (edge) between different forest stages. Many species require multiple structural stages of forests to meet different phases of their life history needs. According to IWAP, “Fire suppression and reduced cutting for firewood and wood products are changing the nature of Iowa’s forests. Habitats for birds that inhabit mature forests (warblers and thrushes) appear to be increasing at the expense of species requiring earlier successional stages.” (IWAP 2012 revision: 94). Examples of early successional species are several migratory songbird species; game species such as ruffed grouse (*Bonasa umbellus*) and American woodcock (*Scolopax minor*); cottontail rabbit (*Sylvilagus floridanus*); and a host of Lepidoptera (butterflies and moths), small mammals, and reptiles (Stambaugh 2014). Indiana bat and other bat species are also known to feed on insects common to young forests (Clark et. al. 1987, Loeb and O’Keefe 2006). Abundance and trends in structural and successional stages serve as indicators of population carrying capacity for wildlife species (Hunter et al. 2001). Historical trends in Iowa’s forest habitats are reported for timberland, which accounts for about 96 percent of all forest land in the State. For current habitat conditions, estimates are reported for all forest land.

What we found

Abundance of large diameter stand-size class has increased steadily in Iowa during the past several decades, making up 39 percent of timberland in 1954, and nearly 70 percent today. Medium and small diameter stand-size classes have increased only slightly in area despite the substantial increase in total forest land area during recent decades (Fig. 54). Since 1990, timberland area less than 20 years of age has decreased by more than 40 percent. Area in other age classes changed moderately, increasing in some classes and decreasing in others (Fig. 55). Timberland older than 100 years has the smallest area of any age class, a pattern that has been consistent over the past two decades (Fig. 55).

In Iowa, all three stand-size classes contain forests of multiple ages (Fig. 56). In the medium diameter stand-size class, forest of 21-60 years of age predominates, with lower abundance of both young (0 to 20 years) and old (more than 60 years) forest.

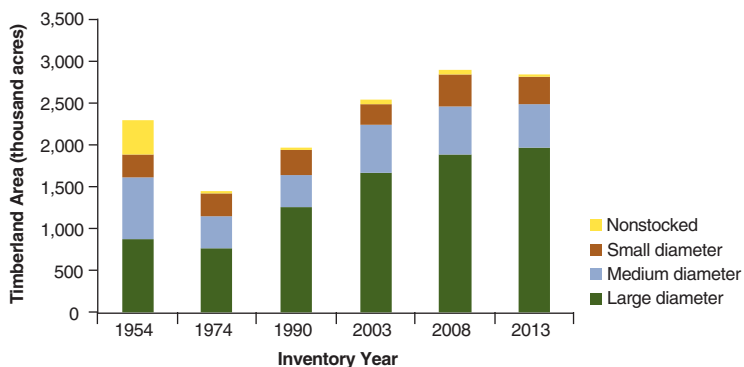


Figure 54.—Area of timberland by stand-size class, Iowa, 1954-2013.

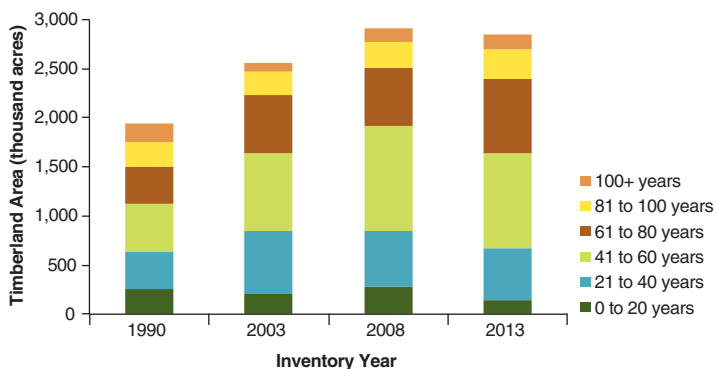


Figure 55.—Area of timberland by stand-age class, Iowa, 1990-2013.

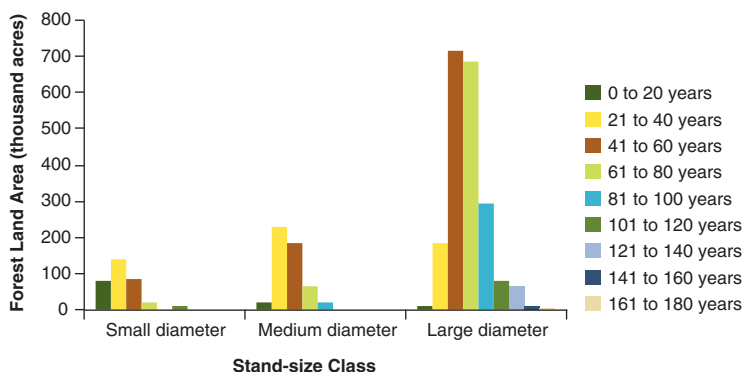


Figure 56.—Area of forest land by stand-age class and stand-size class, Iowa, 2009-2013.

Somewhat surprisingly, the most abundant age classes in small diameter forest are also in the 21- to 60-year class, not the 0- to 20-year class (Fig. 56). In the large diameter stand-size class, forest of the 41- to 80-year class predominates; as expected, almost all forest older than 80 years is of large diameter size-class (Fig. 56). See also Tree Density, Size, and Stocking section on p. 29.

What this means

Large diameter stand-size class has more than doubled in area over the past several decades. Timberland over 100 years of age amounts to only 5 percent of total area, but has nearly doubled in area during the past decade. Area of small diameter stand-size class has not kept pace with the increasing total area of timberland. Stand-size class and stand-age class are complementary indicators of forest structural/successional stage. Forests between 21 and 100 years of age contain at least some fraction of all three stand-size classes. As expected, there is very little small diameter forest in the oldest stand age classes and very little large diameter forest in the youngest stand-age class. The two age classes with the most size heterogeneity are 21- to 40-year and 41- to 60-year classes. Such mixtures of different-aged or -sized trees provide a vertical diversity of vegetation structure that can enhance habitat conditions for some wildlife species. There is a need to maintain forest conditions in both smaller and larger structural stages to maintain both early and late successional habitats for all forest-associated species. Managing forest composition and structure in a variety of conditions helps to conserve habitat and viable populations of many forest-associated wildlife species. See Regeneration Status section on p. 64 for more detail on seedling and sapling abundance.

Standing Dead Trees

Background

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.” According to one definition, “for wildlife habitat purposes, a snag is sometimes regarded as being at least 10 in (25.4 cm) in diameter at breast height and

at least 6 ft (1.8 m) tall” (Society of American Foresters 2008). Standing dead trees serve as important indicators not only of wildlife habitat, but also of past mortality events and carbon storage. They also serve as sources of down woody materials (discussed in the Down Woody Materials section on p. 55), 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 Iowa’s forests.

What we found

FIA plot data contain information on standing dead trees (at least 5 inches d.b.h. or diameter at root collar [d.r.c.]) of numerous species and sizes in varying stages of decay. According to current inventory data (2009-2013), almost 36 million standing dead trees are present on Iowa forest land. This equates to an overall density of 12.1 standing dead trees per acre of forest land, with similar densities on public (12.8) and private (12.0) forest land. Nine species groups each contributed more than 1 million standing dead trees; the largest contributor, other eastern soft hardwoods group (more than three-fourths of which are elms) had nearly 20 million snags (Fig. 57). Relative to the total number of live trees in each species group (of at least 5 inches d.b.h. or d.r.c.), four species groups exceeded 10 standing dead trees per 100 live trees, with eastern white and red pine species group topping the list at 41 standing dead trees per 100 live trees (of at least 5 inches d.b.h. or d.r.c.) (Fig. 58). The great majority (70 percent) of standing dead trees were smaller than 11 inches d.b.h., with 34 percent between 5 and 6.9 inches d.b.h.; 6 percent were 17 inches or larger (Fig. 59). Only 14 percent of standing dead trees were in the two classes of most decay (in which few or no limb stubs remain, or no evidence of branches remains); the other three decay classes were fairly evenly distributed, ranging from 24 to 35 percent of all standing dead trees in each class (Fig. 59).

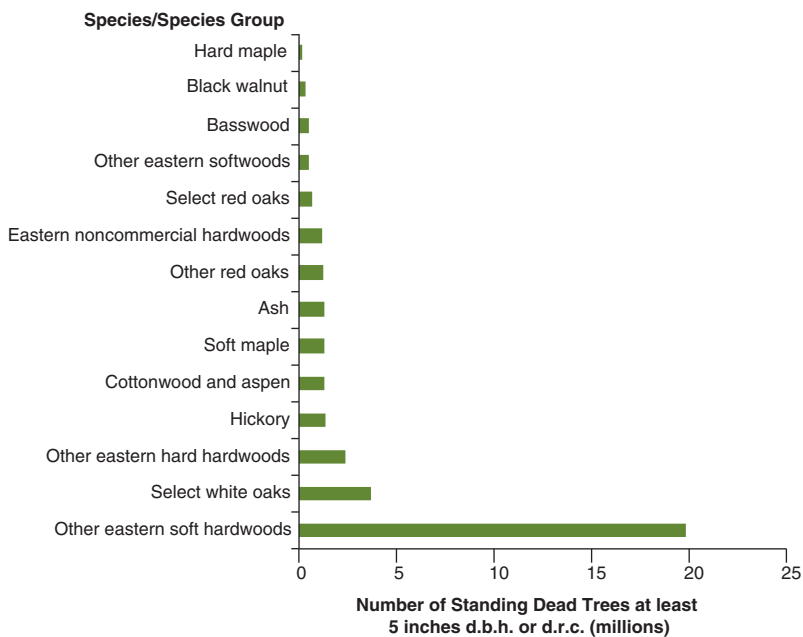


Figure 57.—Number of standing dead trees by species or species group for the 14 most common standing dead tree species groups, Iowa, 2009-2013.

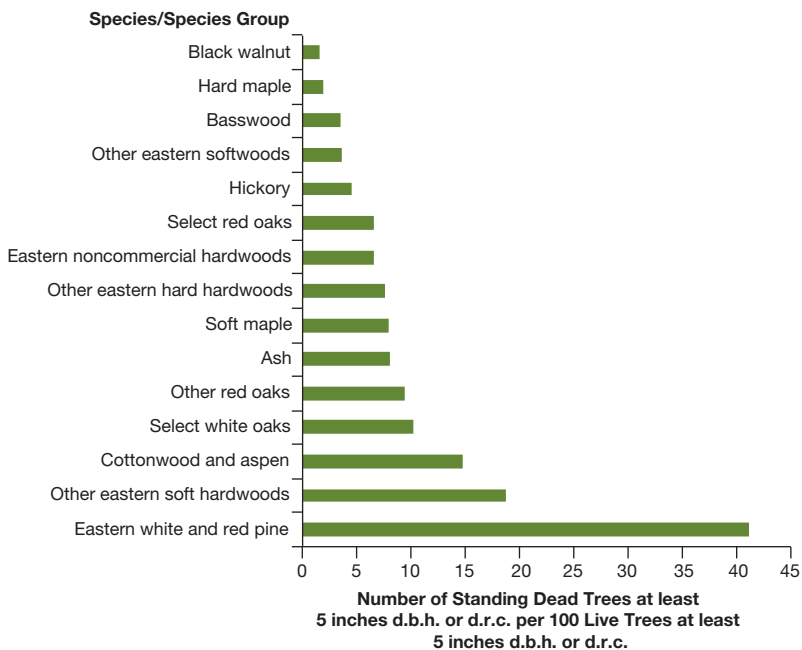


Figure 58.—Number of standing dead trees per 100 live trees for the 15 most common standing dead tree species groups, Iowa, 2009-2013.

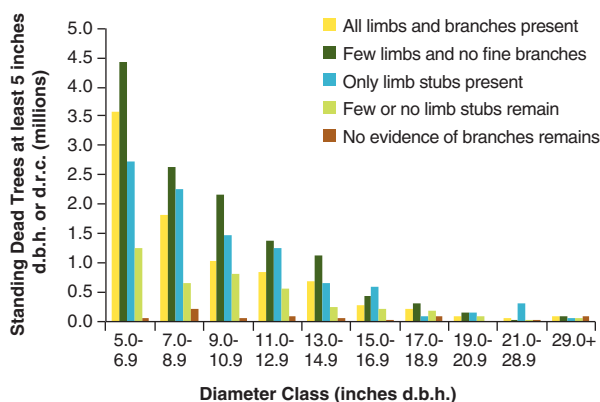


Figure 59.—Distribution of standing dead trees by decay and diameter classes for all dead trees in Iowa, 2009-2013.

What this means

Snags and smaller standing dead trees result from a variety of potential causes, including diseases and insects, weather damage, fire, flooding, drought, and competition. Other eastern soft hardwoods species group contained the largest number of standing dead trees, but eastern red and white pine species group had the highest density of standing dead trees per 100 live trees. About 10 standing dead trees were present for every 100 live trees (of at least 5 inch d.b.h. or d.r.c.). But dead trees may contain significantly more cavities per tree than occur in live trees (Fan et al. 2003), thereby providing a disproportionate number of habitat features for foraging, nesting, roosting, hunting perches, and cavity excavation for wildlife. Species that benefit from these features range from primary colonizers such as insects, bacteria, and fungi to birds, mammals, and reptiles. Most cavity nesting birds are insectivores which help to control insect populations. The availability of very large standing dead trees (snags) may be a limiting mesofilter 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 managers maintain the abundance and quality of habitat for forest-associated wildlife species in Iowa.

Tree and Bird Species Projections

Background

Climate change can alter species' habitats, and these impacts may intensify if the climate continues to depart from current conditions. It is important that we begin to consider the impact of shifting habitats for species and management options in light of climate change. Species distribution models are important tools used to evaluate potential responses to changes. Across the eastern United States models of species' current distributions and potential future habitat are considering the response of 147 bird species' habitats and 134 tree species' habitats to climate change (Matthews et al. 2011). These models provide insights into the important climate and edaphic variables that shape distributions and an understanding of how changes in conditions may affect species' habitats.

What we found

In Iowa, 71 tree species are projected to have habitat suitable by the end of the century (2100). Of these, 15 tree species, including white oak and shagbark hickory, have the potential to lose at least 20 percent of their current suitable habitat. Other important trees of the State, such as American elm, bur oak, and silver maple, are projected to remain fairly stable in habitat conditions. Nearly 35 tree species currently in the State are projected to increase in habitat, such as boxelder and pin oak. Others, such as yellow poplar, may find new habitat in the area.

For birds, the potential change in habitat dynamics under climate change scenarios also spans the domain of potential gains and losses of habitat; 117 bird species are projected to find current or potential future habitat in Iowa. Of these, 33 species are projected to have declines in habitat of at least 20 percent and 40 are projected to have increases in habitat. Some of these species reflect important forest associations in their distributions, and their future habitat dynamics most likely will be influenced by shifts in both tree species habitat and climate. Declines in habitat are projected for ruffed grouse, blue-winged warbler (*Vermivora cyanoptera*), and least flycatcher (*Empidonax minimus*). Habitat gainers may include yellow-billed cuckoo (*Coccyzus americanus*), whip-poor-will (*Antrostomus vociferus*), Acadian flycatcher (*Empidonax traillii*), prothonotary warbler (*Protonotaria citrea*), Kentucky warbler (*Geothlypis formosa*), and black-and-white warbler (*Mniotilta varia*). Habitat for wood thrush (*Hylocichla mustelina*) is expected to persist at current abundance.

What this means

These models for trees and birds reflect how climate change has the potential to reshape the suitability of habitat within the State. Limited data, scenario-specific variability, and omission of specific habitat features all contribute to model uncertainty, so projections should be viewed as one possible outcome, not as definite predictions of the future. Planning and assessment of potential vulnerabilities of tree and bird species will be important if the climate continues to change.

Forest Economics



Red oak rising in Nodaway Valley Park, Page County, Iowa. Photo by Lindsey Barney, Iowa Department of Natural Resources, used with permission.

Growing-stock Volume

Background

Growing-stock volume is the amount of sound wood in live, commercial tree species for trees of at least 5 inches d.b.h. and reasonably free of form defect on the merchantable bole. This measure has long been used to assess wood volume available for commercial use, which is an important consideration in economic planning and evaluations of forest sustainability.

What we found

Total growing-stock volume on Iowa's timberland has more than doubled since the 1954 and 1974 inventories, to a current statewide estimate of over 3 billion cubic feet (Fig. 60). All economically important species groups have shown significant increases since 1990 (Fig. 61). There appear to be slightly increasing growing-stock volumes between 2008 and 2013 inventories. By viewing changes in growing-stock volume by d.b.h. classes, we can see more differences between selected species groups (Fig. 62). In general, diameter distributions from the 2008 and 2013 inventories are similar, with more substantial changes occurring between 1990 and the three more recent inventories. Between the 1990 and 2000s inventories, increases in the smallest diameter class (5.0 to 10.9 inches) were most noticeable for other eastern soft hardwoods species group, in which elms and hackberry species predominate. Black walnut, soft maple, and other eastern soft hardwoods groups all showed substantial increases within the 11.0- to 16.9-inch diameter class. Cottonwood and aspen, select white oaks, and select red oaks exhibited the largest increase in the largest diameter class, 23.0+ inches (Fig. 62). The most notable change in diameter distribution is for black walnut in the 17.0- to 22.9-inch diameter class, which more than doubled in volume during the past decade, and increased by nearly tenfold since 1990 (Fig. 62).

What this means

Growing-stock volume of economically important species groups on timberland has increased substantially since Iowa's earliest statewide inventories in 1954 and 1974, and continued to increase gradually during the past decade. None of the 12 species groups with the greatest volume shows significant volume decreases, although there are early indications that soft maple may be decreasing. Volume increases vary both by species group and diameter class. Sustainability issues (e.g., regeneration) of mature forest stands containing economically vital tree species should continue to be monitored into the future. See Regeneration Status section on p. 64 for more detail.

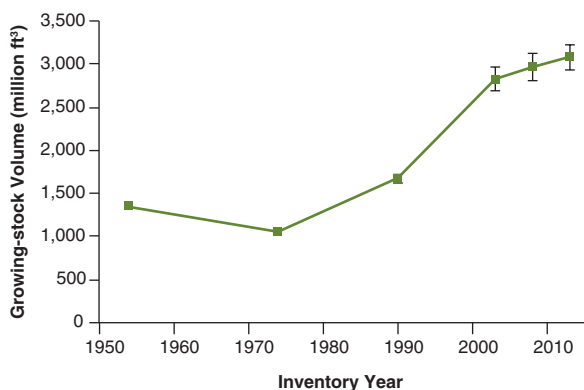


Figure 60.—Total growing-stock volume on timberland, and associated sampling error, Iowa, 1954-2013. Error bars represent a 68 percent confidence interval around each estimate and are available only since 1990.

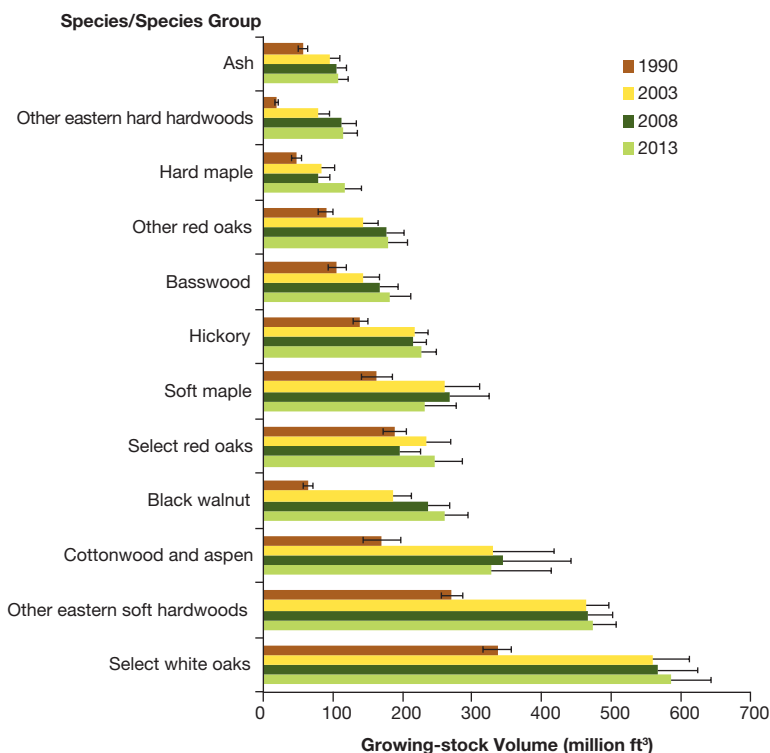


Figure 61.—Total growing-stock volume on timberland by selected species or species groups, and associated sampling error, Iowa, 1990-2013. Error bars represent a 68 percent confidence interval around each estimate.

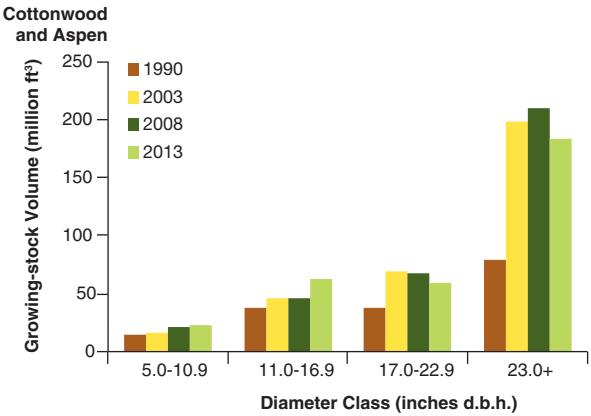
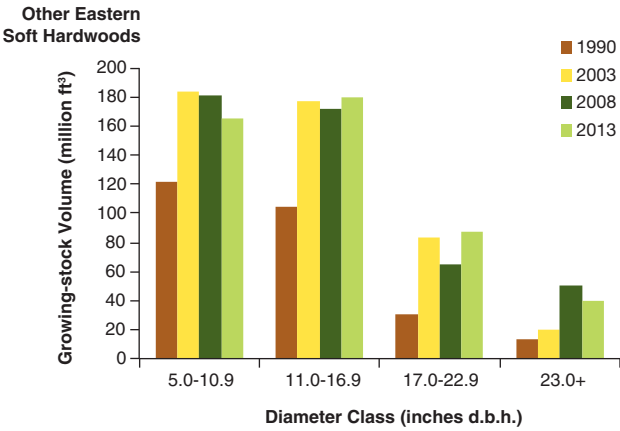
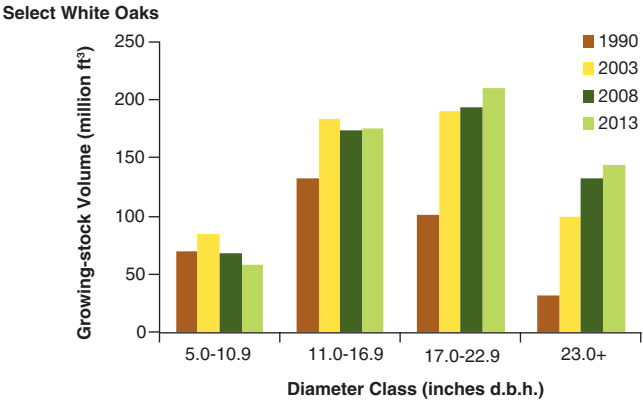
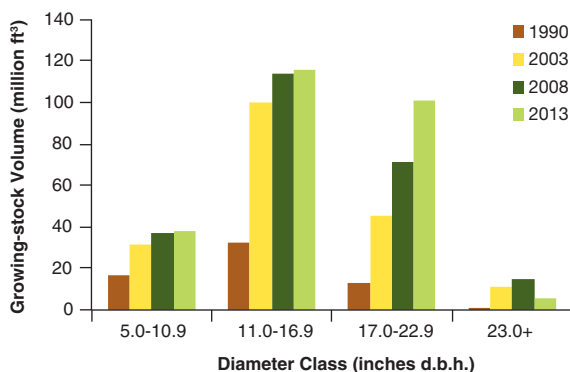
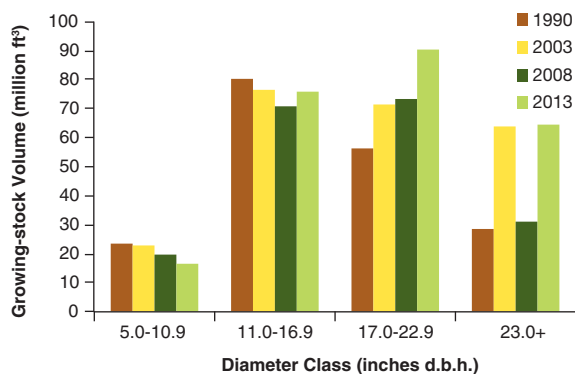


Figure 62.—Growing-stock volume (trees at least 5 inches d.b.h.) on timberland, Iowa, 1990-2013, for six highest volume species or species groups. (Continued on next page)

Black Walnut



Select Red Oaks



Soft Maple

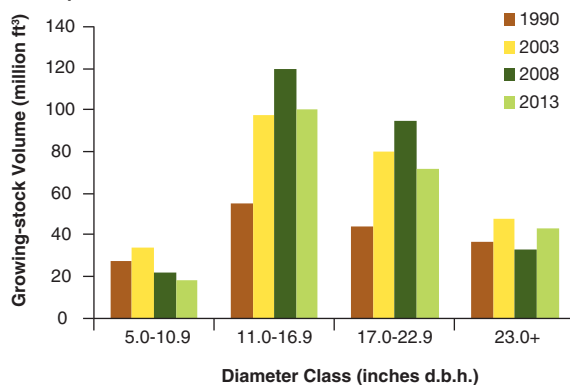


Figure 62. (Continued)—Growing-stock volume (trees at least 5 inches d.b.h.) on timberland, Iowa, 1990-2013, for six highest volume species or species groups.

Sawtimber Volume

Background

Sawtimber trees are live trees of commercial species that contain either one 12-foot or two noncontiguous 8-foot logs. Hardwoods must be at least 11 inches d.b.h. and softwoods must be at least 9 inches d.b.h. to qualify as sawtimber. Sawtimber volume is defined as the net volume of the saw log portion of live sawtimber, measured in board feet, from a 1-foot stump to minimum top diameter (9 inches for hardwoods and 7 inches for softwoods). Estimates of sawtimber volume, expressed as board feet (International 1/4-inch rule), are used to determine the monetary value of wood volume and to identify the quantity of merchantable wood.

What we found

Total statewide board-foot volume of sawtimber on timberland decreased slightly from 1954 to 1974, increased slightly in 1990, then increased substantially to the current inventory estimate of 11.7 billion board feet (Fig. 63). Ten species groups demonstrated gains in sawtimber volume since 2008, and four species groups had decreases (Fig. 64). Hard maple increased the most, at 57 percent. Eastern white and red pine species group decreased the most, corresponding to a high rate of mortality (but with high sampling uncertainty). Other declining species groups include other eastern softwoods, soft maple, and cottonwood and aspen (Fig. 64), all of which had a relatively high ratio of mortality to volume. Relative to total sawtimber volume on timberland, net annual growth dropped from a high of 4.5 percent in 1954 to a low of 2.3 percent during 1974, followed by a return to previous levels in subsequent inventories, and a decline to the current rate of 2.7 percent. Removal rates reveal an opposite pattern, with an increase in 1974 followed by a substantial decrease to the current level of 1.3 percent. During this same period, average annual mortality has increased gradually from a low of 0.5 percent in 1954 to the current rate of 1.5 percent (Fig. 65).

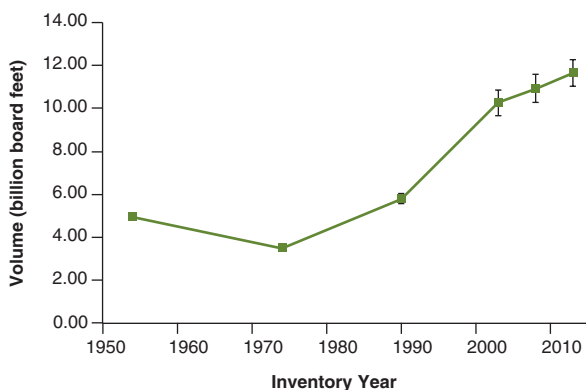


Figure 63.—Volume of sawtimber on timberland, and associated sampling error, Iowa, 1954 to 2009-2013. Error bars represent a 68 percent confidence interval around each estimate and are available only since 1990.

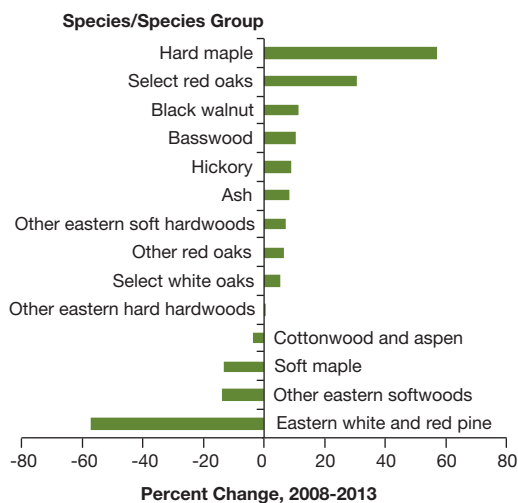


Figure 64.—Percent change in total sawtimber volume on timberland for the 14 highest volume species or species groups, Iowa, 2004-2008 to 2009-2013.

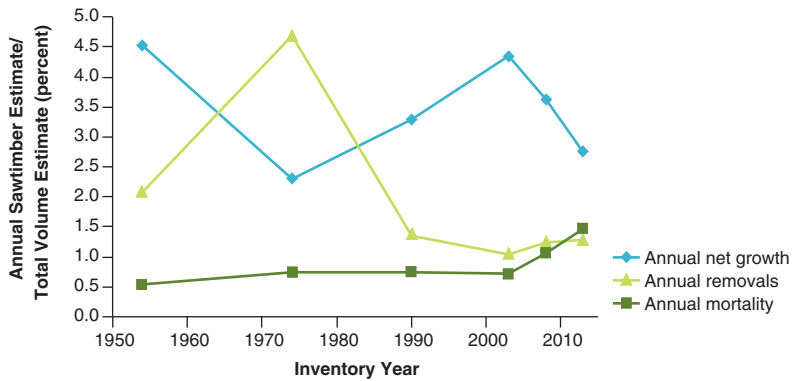


Figure 65.—Total average annual net growth, removals, and mortality as a percentage of total sawtimber volume on timberland, Iowa, 1954 to 2009-2013.

What this means

Sawtimber volume resources on Iowa’s timberland have increased steadily since 1974, with annual rates of net growth exceeding rates of removals. This dynamic indicates that sawtimber on timberland has been a sustainable component of the forest ecosystem. But if current trends were to continue, increasing sawtimber mortality and removals could eventually exceed growth in the future. However, this assumption may not hold locally.

Sawtimber Quality

Background

The economic value of Iowa’s sawtimber lies not only in its absolute amount (volume) but also in its quality. The high quality of hardwood sawtimber across the State indicates its value and supports Iowa’s forest products industries.

What we found

Although grading techniques have changed since previous inventories, it appears that Iowa’s forests have had a major increase in total volume of high quality sawtimber in recent decades. The distribution of sawtimber appears to have increased within the highest tree grade (grade 1) from 13 percent in 1990 to 19 percent in the current inventory (Fig. 66). Other tree grades have shown more moderate fluctuations. Comparisons of recent volumes by grade to inventories from 1990 and earlier are challenging because some sawtimber was not graded during those earlier inventories. Sawtimber in grades 1 and 2 combined totaled 4.7 billion board feet during both the 2003 and 2008 inventories, and 4.6 billion board feet during the 2013 inventory; some species groups had stable or decreasing volumes, but others, such as hard maple, select red oaks, and ash, had increasing volumes (Fig. 67).

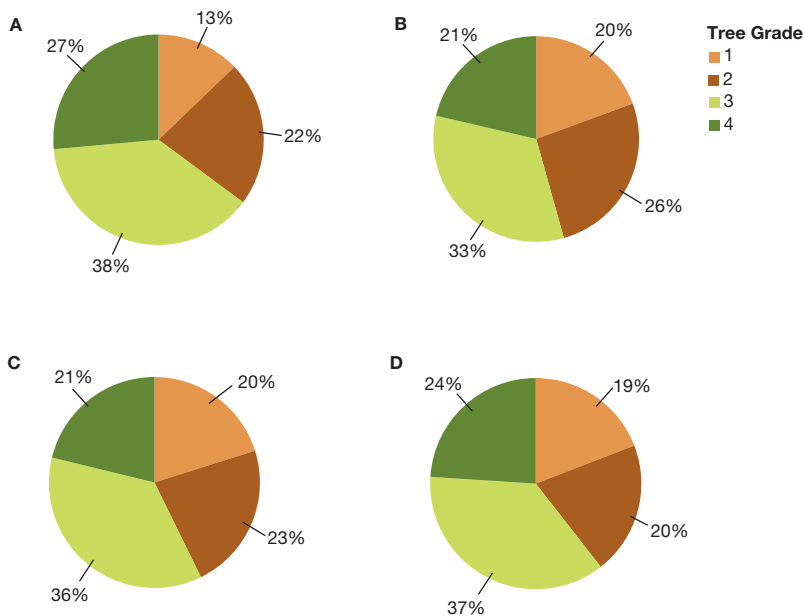


Figure 66.—Distribution of sawtimber volume on timberland by tree grade, Iowa, 1990 (A), 1999-2003 (B), 2004-2008 (C), and 2009-2013 (D).

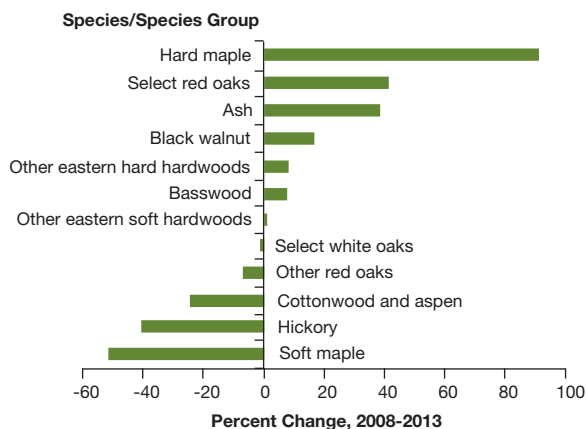


Figure 67.—Percent change in high grade sawtimber volume (grades 1 and 2) for selected hardwood species or species groups on timberland in Iowa between 2004-2008 and 2009-2013.

What this means

Iowa’s sawtimber quality has been improving for decades, with substantial increases in the amount of higher grade sawtimber. In recent inventories, changes in sawtimber grades have varied among species groups. Gains in sawtimber volume and tree grades have probably come from individual tree growth. Overall, it appears that the quality of Iowa’s sawtimber resource has increased from past decades and is currently stable.

Carbon Stocks

Background

Forest resource reporting in recent years has increasingly included estimates of carbon. This is primarily because forests tend to sequester carbon from the atmospheric greenhouse gas carbon dioxide, which is associated with global climate change. Among terrestrial ecosystems, forests contain the largest reserves of sequestered carbon. Regional and national greenhouse gas reporting forums include forest carbon stocks because increases in forest carbon stock represent quantifiable partial offsets to other greenhouse gas emissions. For example, carbon sequestration by U.S. forests provided an offset of more than 11 percent of total U.S. greenhouse gas emissions in 2013 (U.S.

Environmental Protection Agency [EPA] 2015), and the continuing increase in Iowa forest carbon stocks contributes to this effect. Total forest ecosystem carbon stocks in Iowa are estimated to be 169 million tons carbon, a 2 percent increase over 5 years ago. This section provides an overview of carbon in the State's forest lands.

Carbon accumulates in growing trees via the photosynthetically driven production of structural and energy-containing organic (carbon) compounds that primarily accumulate in trees as wood. Over time, this stored carbon also accumulates in dead trees, woody debris, litter, and forest soils. For most forests, the understory grasses and forbs as well as nonvascular plants and animals represent minor pools of carbon stocks. Within soils, the larger woody roots are readily distinguished from the bulk of soil organic carbon, so the roots are generally reported as the belowground portion of trees and not included in the soils estimates. Carbon loss from a forest stand can include mechanisms such as respiration (including live trees and decomposers), combustion, runoff or leaching of dissolved or particulate organic compounds, or direct removal such as the harvest and utilization of wood. From the greenhouse gas reporting perspective, it is important to note that not all losses result in release of carbon dioxide to the atmosphere; some wood products represent continued long-term carbon sequestration.

The carbon pools discussed here include living plant biomass (live trees at least 1 inch d.b.h. and understory vegetation), dead wood and litter (standing dead trees, down dead wood, and forest floor litter; in other words, nonliving plant material), and soil organic matter exclusive of coarse roots and estimated to a depth of 1 meter (3.3 feet). The FIA program does not directly measure forest carbon stocks in Iowa. Carbon estimates, by ecosystem pool, are based on sampling and modeling; for additional information on current approaches to determining forest carbon stocks see U.S. EPA (2015), U.S. Forest Service, Forest Inventory and Analysis (2014), and O'Connell et al. (2014). The level of information available for making the carbon estimates varies among pools. For example, confidence is greatest in estimates of live tree carbon due to the level of sampling and availability of allometric relationships applied to the tree data. Lower confidence is associated with soil organic carbon estimates because of limited data and high variability. Interpretation of these estimates is therefore limited. Ongoing research is aimed at improving the estimates (U.S. EPA 2015). The carbon estimates provided here for Iowa's forests are consistent with the data and methods used to develop the forest carbon reported in the U.S. EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013 (U.S. EPA 2015).

What we found

The average relative proportions of total forest carbon within Iowa forest ecosystems are shown in Figure 68. Live trees and soil organic carbon account for 88 percent of forest carbon stocks, with more than a quarter of all carbon in the wood and bark of the bole of trees at least 5 inches d.b.h. Figure 69 illustrates average tons of carbon per acre on forest land by six stand-age classes for aboveground biomass (live tree and understory) versus aboveground nonliving (standing dead, down dead, and litter) pools. The average number of tons of carbon per acre on forest land increases with stand age, and greater net accumulation is within the biomass component. Total carbon stocks are the product of per-acre carbon and total acres of forest within each age class. More than 60 percent of total aboveground carbon stocks are represented by the middle two age classes (more than 30 percent each); in contrast, the youngest and oldest age classes together account for less than 10 percent of forest carbon stocks.

Species composition can affect carbon stocks. Figure 70 illustrates this with average tons carbon per acre on forest land by common Iowa forest-type groups. Carbon tons per acre on forest land is provided according to four classifications: biomass (live tree and understory), dead wood (standing dead trees and down dead wood), litter, and soil. Note that the sometimes considerable variability among forest-type groups is most closely associated with variability in biomass (which is essentially live tree; see Figure 68). Again, total stocks are the product of tons carbon per acre on forest land and acres of forest land, and in Iowa more than 90 percent of total carbon stocks are in the two most common forest-type groups: oak/hickory and elm/ash/cottonwood. The largest single pool is biomass within the oak/hickory forest-type group: 54 million tons carbon or about 32 percent of all Iowa forest carbon stocks.

Actual stocks for a particular stand will depend on a combination of influences, such as site history, management, stand age, or component species. Consequently individual sites can differ from the summaries provided in Figures 68, 69, or 70. As an example, the statewide average tons of carbon per acre on forest land for live trees is 36 for stands that are identified as fully stocked, but the site-to-site variability is such that 50 percent of measured plots fall between 28 and 45 tons carbon per acre on forest land. Greater carbon tons per acre on forest land occur in 25 percent of measured plots, and lower levels occur in the remaining 25 percent.

The current carbon estimation methods and data were also applied to the 2008 Iowa forest inventory (data not shown) to produce summaries consistent with those provided here for the 2013 inventory. Overall forest carbon tons per acre on forest land increased by 4 percent relative to 5 years ago, and live tree carbon values

increased by 9 percent. These increases in per-acre carbon meant that despite the 2 percent decrease in forest area, total carbon stocks in 2013 were 2 percent greater than the equivalent values calculated for 2008.

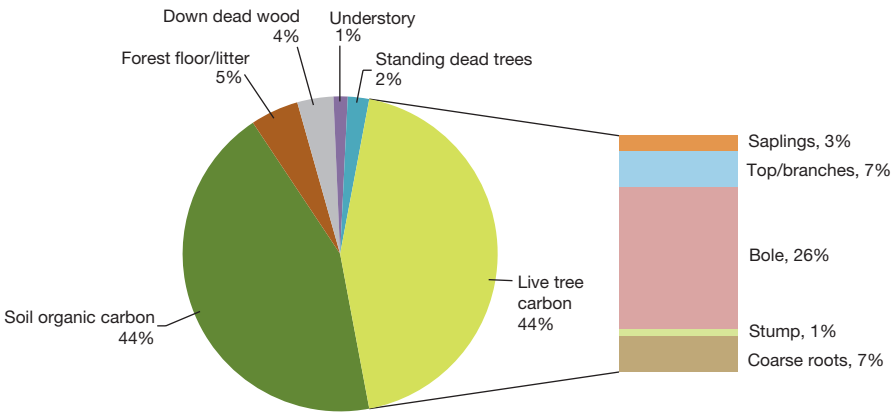


Figure 68.—Percentage of total forest carbon stocks within each of the listed classifications, Iowa, 2013. Note that live tree carbon is subdivided into live saplings (d.b.h. of 1-5 inches, 3 percent of total) and trees at least 5 inches d.b.h. (41 percent of total), which are further divided into four components.

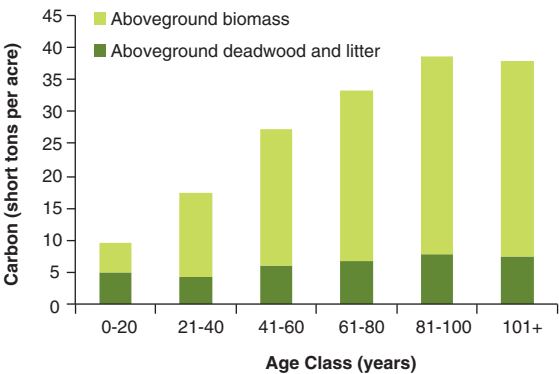


Figure 69.—Average per-acre carbon stocks on forest land according to six stand-age classes for aboveground biomass (live tree and understory) versus nonliving (standing dead, down dead, and litter) pools, Iowa, 2013.

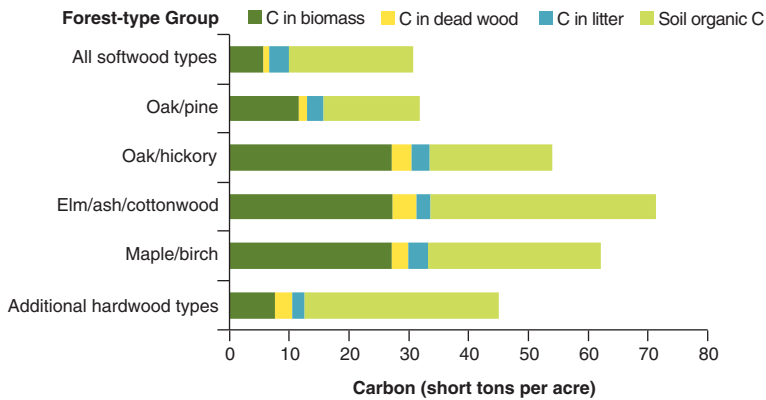


Figure 70.—Average per-acre carbon stocks on forest land according to forest-type group by four classifications—biomass (live tree and understory), dead wood (standing dead trees and down dead wood), litter, and soil—Iowa, 2013. The less common forest-type groups are pooled as the softwood or additional hardwood types.

What this means

In general, forest carbon stocks or differences in stock broadly reflect other measures of forest resources such as stand age, volume, or stocking. However, these summaries offer a reference measure of carbon stocks for the State relative to published regional or national forest carbon reports, thereby providing a ready estimate of the role of Iowa’s forests.

Timber Products Output

Background

The harvesting and processing of timber products produces a stream of income shared by timber owners, managers, marketers, loggers, truckers, and processors. In 2013, the wood products and paper manufacturing industries in Iowa employed 11,898 people, with an average annual payroll of \$648 million (U.S. Department of Labor 2015). To better manage the State’s forests, it is important to know the species, amounts, and locations of timber being harvested. A survey of Iowa wood-processing mills was last conducted for 2005. For this report, the 2010 information is based on an adjustment of the 2005 survey and the harvesting trends of surrounding states that were receiving wood products from Iowa (Illinois 2010, Indiana 2008, Michigan

2010, Minnesota 2010, Missouri 2009, Nebraska 2009, Virginia 2009, and Wisconsin 2009). In 2005, 27 active primary wood-processing mills were surveyed to determine the species that were processed and where the wood material came from (Haugen and Michel 2010).

What we found

In 2010, 13.6 million cubic feet of industrial roundwood was harvested from Iowa’s forest land, a decrease of 16 percent from 2005 (Fig. 71). Saw logs accounted for more than 90 percent of the total industrial roundwood harvested. Other products harvested were veneer logs, cooperage, and industrial fuelwood. White and red oaks accounted for more than 35 percent of the total industrial roundwood harvest (Fig. 72). Other important species groups harvested were the maples, black walnut, and cottonwood. In the process of harvesting industrial roundwood, 9.4 million cubic feet of harvest residues were left on the ground. The processing of industrial roundwood generated 250,000 dry tons of wood and bark residues. Eighty-three percent of the mill residues generated were used for miscellaneous products such as mulch or animal bedding. Another 15 percent of the mill residues were used for industrial and residential fuelwood, and 2 percent was used for fiber products (Fig. 73).

In 2013, the number of employees working in the forest products industry increased from the previous year for the first time since 2005 (Fig. 74). Although the number of employees decreased by 28 percent between 2007 and 2012, the total annual wages (actual dollars) decreased by only 17 percent (U.S. Census Bureau 2015). The total value of shipments decreased by 22 percent between 2007 and 2009, then increased by 20 percent between 2009 and 2012 to reach the same level as they were in 2005.

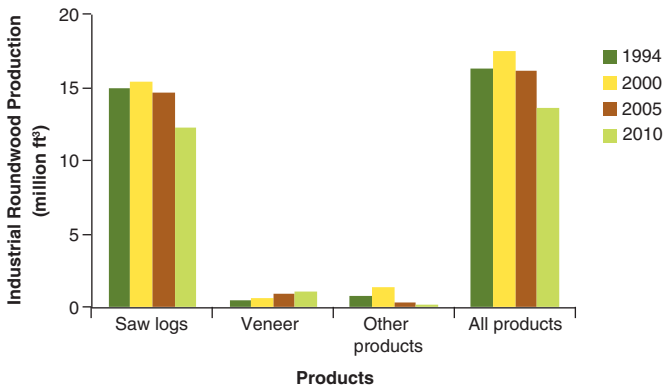


Figure 71.—Industrial roundwood production by product and year, Iowa.

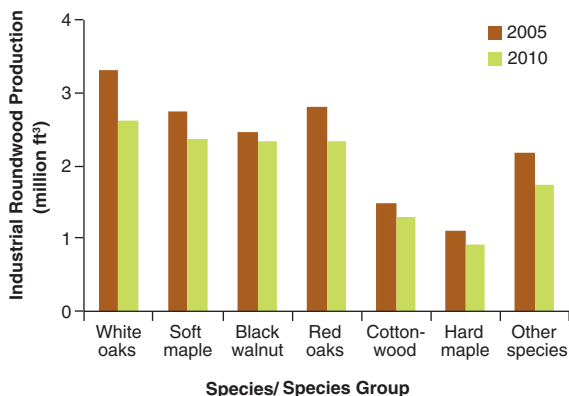


Figure 72.—Industrial roundwood harvested by species or species group, Iowa, 2005 and 2010.

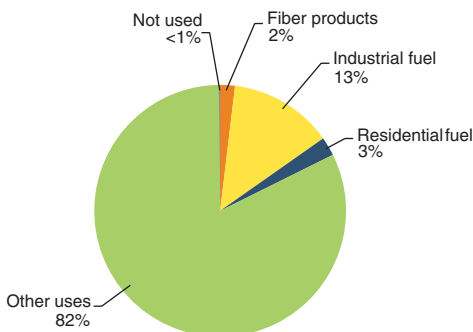


Figure 73.—Disposition of mill residues generated by primary wood-using mills, Iowa, 2010.

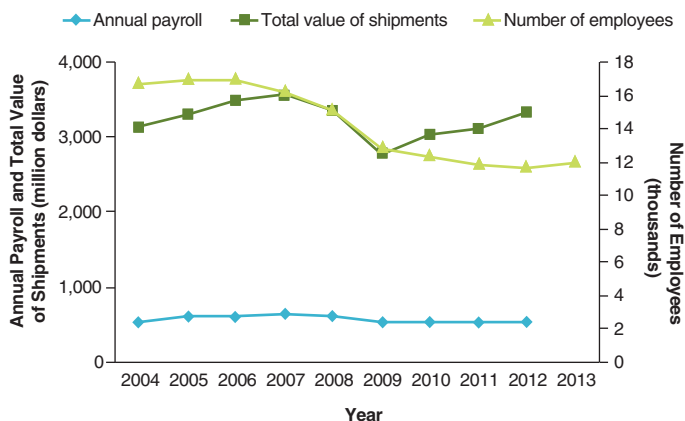


Figure 74.—Number of employees, annual payroll, and total value of shipments for the forest products industry, Iowa, 2004-2013.

What this means

The increase in total value of shipments between 2009 and 2012 reflects the increase in demand for higher value forest products such as white oak cooperage and black walnut veneer, much of which is being exported to other countries. As the economy improves, and the demand for wood products increases, the forest products mills that were able to withstand the recession are beginning to increase their production, resulting in an increase in the number of employees in the forest products industry.

Another important issue is the volume of harvest residues that are generated in the State that go unused. More than 30 percent of the harvest residue is from growing-stock sources (wood material that could be used to produce products). Iowa's primary forest products industry is the processing of saw logs. The last pulp mill in the State closed in 2005. Without this market, a large volume of usable, small dimension wood material above the saw log top is left behind. Small, localized, industrial fuelwood or wood pellet manufacturers have the opportunity to better utilize the forest resource.

Future Forests



Quaking aspen fall color, Johnson County, Iowa. Photo by Mark Vitosh, Iowa Department of Natural Resources, used with permission.

Forest Land Projections

This section focuses on anticipated changes to Iowa’s forests between 2010 and 2060. The Northern Forest Futures study (Shifley and Moser 2016) examined several alternative future scenarios that cover a range of different assumptions about the economy, population, climate, and other driving forces that will affect the future conditions of forests. The assumptions were incorporated into analytical models that estimated how northern forests are likely to change under each alternative scenario. The seven scenarios can be grouped by climate model (or “general circulation model”), storyline, and storyline variation. Two climate models, three storylines, and three variations were used to produce the seven scenarios listed in Table 9. Additional details on methods can be found in Shifley and Moser (2016).

Table 9.—Scenarios used to project future forest conditions for Iowa

General circulation model ^a	IPCC ^b Storyline A1B	IPCC Storyline A2	IPCC Storyline B2
CGCM3.1	Scenario A1B-C	Scenario A2-C	
	Scenario A1B-BIO	Scenario A2-BIO	
		Scenario A2-EAB	
CGCM2			Scenario B2-C
			Scenario B2-BIO

a Source for these two coupled global climate models: Canadian Centre for Climate Modelling and Analysis (2012).

b IPCC is the Intergovernmental Panel on Climate Change.

A large component of future forest change will be the result of normal forest growth, aging, natural regeneration, and species succession. In addition, external forces are expected to drive forest change as follows:

- Population increases will cause roughly 150,000 acres of Iowa’s forest land to be converted to urban land (Nowak and Walton 2005)
- Economic conditions will affect forest products consumption, production, and harvest rates
- Invasive species will spread and affect forest change
- Changes in population, the economy, energy consumption, and energy production will affect climate
- Climate change will affect long-term patterns of forest growth and species succession.

Following are the three storylines, as developed by the Intergovernmental Panel on Climate Change (IPCC 2000), with a brief description of the characteristics of each:

1. A1B—Rapid economic globalization. International mobility of people, ideas, and technology. Strong commitment to market-based solutions. Strong commitment to education. High rates of investment and innovation in education, technology, and institutions at the national and international levels. A balanced energy portfolio that includes fossil fuel-intensive sources and renewable energy sources.

2. A2—Consolidation into economic regions. Self-reliance in terms of resources and less emphasis on economic, social, and cultural interactions between regions. Technology diffuses more slowly than in the other scenarios. International disparities in productivity, and hence in per capita income, largely persist or rise in absolute terms.

3. B2—A trend toward local self-reliance and stronger communities. Community-based solutions to social problems. Energy systems differ from region to region, depending on the availability of natural resources. The need to use energy and other resources more efficiently spurs the development of less carbon-intensive technology in some regions.

Descriptions of the three storyline variations are as follows:

1. C—Variations of the A1B, A2, and B2 storylines examine effects resulting from a continuation of the observed recent rates of forest removals due to timber harvesting and land use conversion from forest to another land use. These variations are referred to as scenarios A1B-C, A2-C, and B2-C.

2. BIO—Variations of the A1B, A2, and B2 storylines look at impacts of increased harvest and utilization of woody biomass for energy. They are referred to as scenarios A1B-BIO, A2-BIO, and B2-BIO.

3. EAB—A variation of the A2 storyline examines the potential impact of the continued spread of the emerald ash borer with associated mortality of all ash trees in the affected areas. This is referred to as scenario A2-EAB.

The anticipated declines in forest land amount to tens of thousands of acres (Fig. 75). Specifically, over the next 50 years forest land area is projected to decline from an estimated 3.033 million acres in 2010 to 2.915 million acres (a loss of 4 percent) in 2060 under scenario A1B-C, to 2.953 million acres (a loss of 3 percent) under scenario A2-C, and to 2.977 million acres (a loss of 2 percent) under scenario B2-C. Only the storylines (developed around differing expectations of demographics and levels of economic activity) alter the projected area of forest land, scenarios with greater increases in population and economic activity project less future forest land. Because the choice of climate model and variations on the storylines do not affect projections of forest land area, only the three scenarios are represented in Figure 75. The projected losses of forest land from 2013 to 2060 are small compared to the cumulative increase in forest area since the start of the 20th century.

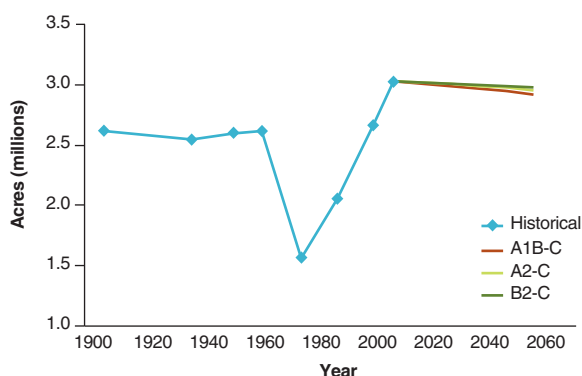


Figure 75.—Past and projected forest land area by scenario, Iowa, 2010-2060.

Emerald ash borer (EAB) was detected in Iowa in spring 2010. Under scenario A2-EAB (Fig. 76) there is a sharp decrease in the area of elm/ash/cottonwood projected by 2060 as EAB is expected to virtually eliminate the ash tree resource. Ash species are less than 4 percent (146 million cubic feet) of the total live-tree volume in Iowa (Fig. 77), so the impacts of EAB will not be as obvious as in other areas of the northeastern United States, where ash trees are more abundant. Nevertheless, 16 million ash trees at least 5 inches d.b.h. are likely to be lost from Iowa forest land (see also Insects and Disease Pathogens section on p. 51). By 2060 under all future scenarios, the oak/hickory forest-type group is expected to increase in forest area, and the elm/ash/cottonwood forest-type group is expected to decrease in forest area.

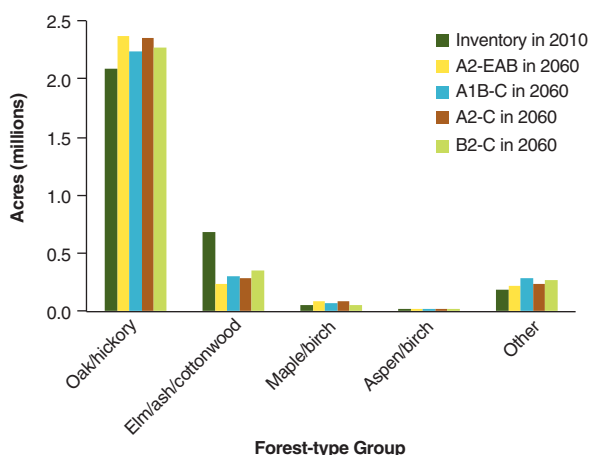


Figure 76.—Forest land area by forest-type group, Iowa, 2010 and by scenario in 2060.

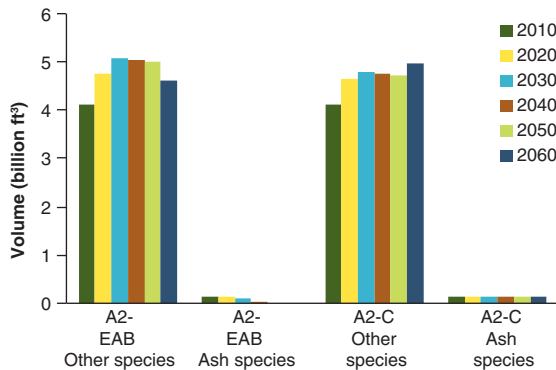


Figure 77.—Past and projected live-tree volume for ash species and for all other species on forest land for scenarios A2-EAB and A2-C, Iowa, 2010-2060.

The direct impacts of EAB-caused ash tree mortality are more pronounced when viewed in terms of forest volume rather than forest area (Fig. 78). For all scenarios live-tree volume is projected to peak in 2020 or 2030. After 2050 the A2-EAB scenario predicts a far more rapid decline in volume than the corresponding scenario modeled without projected losses to EAB (scenario A2-C).

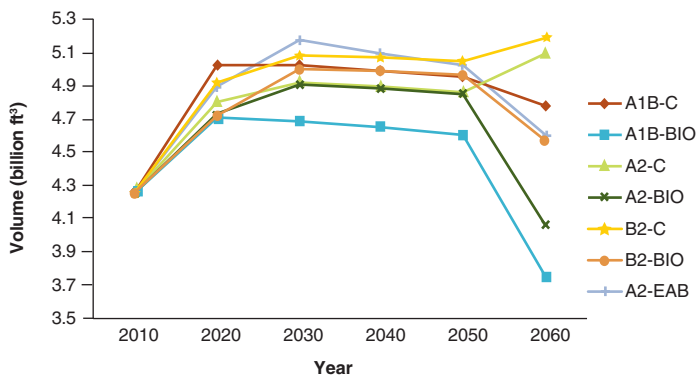


Figure 78.—Past and projected live-tree volume on forest land by scenario, Iowa, 2010-2060.

The scenarios (Fig. 78) with accelerated biomass removal for energy production (A1B-BIO, A2-BIO, and B2-BIO) show substantial declines in standing volume after 2050, comparable to or greater than declines in the EAB scenario. This does not mean that increased utilization of biomass for energy is ill advised. Rather, forest managers

will need to be prudent about how much biomass is utilized and how it is obtained and replenished.

Under the scenarios with a continuation of current removals rates (A1B-C, A2-C, and B2-C), the live-tree volume is expected to increase until about 2030 (despite losses in forest land area). For the next 20 years all three scenarios have volumes just below the high levels set in 2030. Surprisingly, from 2050 to 2060 scenario B2-C and A1B-C achieve new highs whereas scenario A1B-C drops below 2030 levels. Although the total area of forest land is expected to decrease, the volume per acre in these three scenarios is expected to increase as forests continue to mature. In the past 50 years forest managers have had the luxury of rapidly increasing forest volume with growth greatly exceeding removals. If these projections hold true, that may not be the case for future generations of forest managers and wood-using industries. This trend results from the combined effects of gradually decreasing forest area and an aging forest resource with high volume but low net growth per acre.

Data Sources and Techniques

Forest Inventory

Information on the condition and status of forests in Iowa was obtained from the Northern Research Station's Forest Inventory and Analysis (NRS-FIA) program. Previous inventories of Iowa's forest resources were completed in 1954 (Thornton and Morgan 1959), 1974 (Spencer and Jakes 1980), 1990 (Leatherberry et al. 1992), 2003 (Leatherberry et al. 2006), and 2008 (Nelson et al. 2011). Data from Iowa's forest inventories are available online at <http://www.nrs.fs.fed.us/fia/>. For detailed information on inventory methods, see the Statistics, Methods, and Quality Assurance section at <http://dx.doi.org/10.2737/NRS-RB-102>.

National Woodland Owner Survey

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

Timber Product Output Inventory

This study was a cooperative effort of the Division of Forestry of the Iowa Department of Natural Resources and the U.S. Forest Service's Northern Research Station (NRS). Using a questionnaire designed to determine the size and composition of Iowa's forest products industry, its use of roundwood (round sections cut from trees), and its generation and disposition of wood residues, Iowa Division of Forestry personnel visited all "known" primary wood-using mills within the State. Completed questionnaires were sent to NRS for processing and analyses. As part of data processing and analyses, all industrial roundwood volumes reported on the questionnaires were converted to standard units of measure by using regional conversion factors. Timber removals by source of material and harvest residues generated during logging were estimated from standard product volumes by using factors developed from logging utilization studies previously conducted by NRS.

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Appendix—List of tree species, greater than or equal to 1 inch in diameter, found on FIA inventory plots, Iowa, 2009-2013

Common name	Genus	Species	Species code	Species group code
Ailanthus	<i>Ailanthus</i>	<i>altissima</i>	341	43
American basswood	<i>Tilia</i>	<i>americana</i>	951	38
American elm	<i>Ulmus</i>	<i>americana</i>	972	41
American hornbeam, musclewood	<i>Carpinus</i>	<i>caroliniana</i>	391	43
American plum	<i>Prunus</i>	<i>americana</i>	766	43
American sycamore	<i>Platanus</i>	<i>occidentalis</i>	731	41
Apple spp.	<i>Malus</i>	spp.	660	43
Bigtooth aspen	<i>Populus</i>	<i>grandidentata</i>	743	37
Bitternut hickory	<i>Carya</i>	<i>cordiformis</i>	402	29
Black ash	<i>Fraxinus</i>	<i>nigra</i>	543	36
Black cherry	<i>Prunus</i>	<i>serotina</i>	762	41
Black locust	<i>Robinia</i>	<i>pseudoacacia</i>	901	42
Black maple	<i>Acer</i>	<i>nigrum</i>	314	31
Black oak	<i>Quercus</i>	<i>velutina</i>	837	28
Black walnut	<i>Juglans</i>	<i>nigra</i>	602	40
Black willow	<i>Salix</i>	<i>nigra</i>	922	41
Boxelder	<i>Acer</i>	<i>negundo</i>	313	41
Bur oak	<i>Quercus</i>	<i>macrocarpa</i>	823	25
Butternut	<i>Juglans</i>	<i>cinerea</i>	601	41
Chinkapin oak	<i>Quercus</i>	<i>muehlenbergii</i>	826	25
Chokecherry	<i>Prunus</i>	<i>virginiana</i>	763	43
Eastern cottonwood	<i>Populus</i>	<i>deltoides</i>	742	37
Eastern hophornbeam	<i>Ostrya</i>	<i>virginiana</i>	701	43
Eastern redbud	<i>Cercis</i>	<i>canadensis</i>	471	43
Eastern redcedar	<i>Juniperus</i>	<i>virginiana</i>	68	9
Eastern white pine	<i>Pinus</i>	<i>strobus</i>	129	4
Green ash	<i>Fraxinus</i>	<i>pennsylvanica</i>	544	36
Hackberry	<i>Celtis</i>	<i>occidentalis</i>	462	41
Hawthorn spp.	<i>Crataegus</i>	spp.	500	43
Honeylocust	<i>Gleditsia</i>	<i>triacanthos</i>	552	42
Kentucky coffeetree	<i>Gymnocladus</i>	<i>dioicus</i>	571	42
Mockernut hickory	<i>Carya</i>	<i>alba</i>	409	29
Northern catalpa	<i>Catalpa</i>	<i>speciosa</i>	452	41
Northern pin oak	<i>Quercus</i>	<i>ellipsoidalis</i>	809	28
Northern red oak	<i>Quercus</i>	<i>rubra</i>	833	26
Oak spp.	<i>Quercus</i>	spp.	800	42
Ohio buckeye	<i>Aesculus</i>	<i>glabra</i>	331	41
Osage-orange	<i>Maclura</i>	<i>pomifera</i>	641	43
Paper birch	<i>Betula</i>	<i>papyrifera</i>	375	41

(Appendix continued on next page.)

(Appendix continued)

Common name	Genus	Species	Species code	Species group code
Peachleaf willow	<i>Salix</i>	<i>amygdaloides</i>	921	43
Pignut hickory	<i>Carya</i>	<i>glabra</i>	403	29
Pin oak	<i>Quercus</i>	<i>palustris</i>	830	28
Ponderosa pine	<i>Pinus</i>	<i>ponderosa</i>	122	9
Post oak	<i>Quercus</i>	<i>stellata</i>	835	27
Quaking aspen	<i>Populus</i>	<i>tremuloides</i>	746	37
Red mulberry	<i>Morus</i>	<i>rubra</i>	682	42
Red pine	<i>Pinus</i>	<i>resinosa</i>	125	4
River birch	<i>Betula</i>	<i>nigra</i>	373	41
Russian-olive	<i>Elaeagnus</i>	<i>angustifolia</i>	997	43
Serviceberry spp.	<i>Amelanchier</i>	spp.	356	43
Shagbark hickory	<i>Carya</i>	<i>ovata</i>	407	29
Shingle oak	<i>Quercus</i>	<i>imbricaria</i>	817	28
Siberian elm	<i>Ulmus</i>	<i>pumila</i>	974	41
Silver maple	<i>Acer</i>	<i>saccharinum</i>	317	32
Slippery elm	<i>Ulmus</i>	<i>rubra</i>	975	41
Sugar maple	<i>Acer</i>	<i>saccharum</i>	318	31
Swamp white oak	<i>Quercus</i>	<i>bicolor</i>	804	25
White ash	<i>Fraxinus</i>	<i>americana</i>	541	36
White mulberry	<i>Morus</i>	<i>alba</i>	681	42
White oak	<i>Quercus</i>	<i>alba</i>	802	25

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The third full annual inventory of Iowa's forests (2009-2013) indicates that just under 3 million acres of forest land exists in the State, 81 percent of which is in family forest ownership. Almost all of Iowa's forest land is timberland (96 percent), with an average volume of more than 1,000 cubic feet of growing stock per acre on timberland and more than 1,500 cubic feet of all live volume (for trees at least 5 inches diameter at breast height) per acre on timberland. American elm and eastern hophornbeam are the most numerous tree species, but bur oak and silver maple predominate in terms of live-tree volume. Iowa's forest land is composed of 70 percent sawtimber, 17 percent poletimber, and 13 percent sapling/seedling or nonstocked size classes. Average annual net growth of growing-stock trees on Iowa's timberland decreased during the past decade to the current estimate of 71 million cubic feet. This report includes additional information on forest attributes, land-use change, carbon, timber products, wildlife habitat, forest health, and future projections. The following information is available online at <http://dx.doi.org/10.2737/NRS-RB-102>: 1) descriptive information on methods, statistics, and quality assurance of data collection, 2) a glossary of terms, 3) tables that summarize quality assurance, 4) a core set of tabular estimates for a variety of forest resources, and 5) a Microsoft® Access database that represents an archive of data used in this report, with tools that allow users to produce customized estimates.

KEY WORDS: inventory, forest statistics, forest health, wildlife, carbon, FIA

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