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Abstract

The 2015 inventory of the forests of the Northern Great Plains States (Kansas, Nebraska, North Dakota, and South Dakota) reports more than 6.8 million acres of forest land and almost 2.2 billion trees. Forest land is dominated by the ponderosa pine and sugarberry/hackberry/elm/green ash forest types, which together occupy one-third of the total forest land area. The volume of growing stock on timberland currently totals 4.6 billion cubic feet. The average annual net growth of live trees from 2010 to 2015 was nearly 157 million cubic feet per year. This report includes additional information on forest attributes, carbon, timber products, and forest health. The following information is available online at https://doi.org/10.2737/NRS-RB-116: 1) descriptive information on forest inventory statistics, methods, and quality assurance of data collection; 2) tables that summarize quality assurance; 3) a core set of tabular estimates for a variety of forest resources; and 4) a Microsoft® Access database that represents an archive of data used in this report, with tools that allow users to produce customized estimates.

Acknowledgments

The authors would like to thank the many individuals who contributed to this regional assessment of forest resources in the Northern Great Plains. We thank the field crews for their hard work and dedication while collecting the information that is the basis for this report. Special thanks also go to the Northern Research Station's Forest Inventory and Analysis leadership and staff who facilitate data collection efforts and prepare, process, and compile all the data.

Cover: Custer National Forest, South Dakota. Photo by Dacia Meneguzzo, USDA Forest Service.

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Contents

Highlights

On the Plus Side

- Forest land area has increased by almost 200,000 acres for the four-State region and now exceeds 6.8 million acres.
- Nonforest land with trees, an important ecological and economic resource, adds nearly 5.1 million acres of tree-covered land across the region.
- Northern Great Plains forests contain nearly 2.2 billion live trees regionwide.
- Total live biomass continues to increase and is currently estimated at more than 201 million dry tons.

Areas of Concern

- Although forest land is increasing, much of that increase is due to the invasion of pasture and rangeland by eastern redcedar.
- Invasive plant species are found across the four-State region.
- The rate of mortality for ponderosa pine has increased due to large wildfires and the mountain pine beetle.
- Growing-stock volume is decreasing, which may affect the forest resource industry.

Issues to Watch

- Most of the Northern Great Plains forest land is privately owned and will change ownership in the future.
- Ash is a significant component of the Northern Great Plains forests, and the introduction of emerald ash borer will have a detrimental effect on the region's forest resources.
- Other threats to the Northern Great Plains forests include events related to extreme weather, such as drought, wildfire, and insect infestations.
- Most of the growth (85 percent) occurred on only 10 species; this concentration of growth on relatively few species increased from 81 percent in 2010, a cause for concern because this limited number of species is responsible for an even higher percentage of net growth.

Branched Oak State Recreation Area, Lancaster County, Nebraska. Photo by Dacia Meneguzzo, USDA Forest Service.

Background

Forest and nonforest landscape in northwestern South Dakota. Photo by Dacia Meneguzzo, USDA Forest Service.

An Overview of Forest Inventory

What is a tree?

The U.S. Forest Service's Forest Inventory and Analysis (FIA) program defines a tree as any perennial woody plant species with central stems and distinct crowns that can attain a height of 15 feet at maturity. A complete list of the tree species measured in this inventory can be found in Appendix 1. Throughout this report, the size of a tree is usually expressed as diameter at breast height (d.b.h.), in inches. This is the diameter, outside the bark, at a point 4.5 feet above the ground. An electronic record of every tree measured in this inventory is available online at https://doi.org/10.2737/NRS-RB-116. Definitions for "tree" and many other terms in this report are available in the FIA online glossary: https://www.nrs.fs.fed.us/fia/data-tools/state-reports/glossary/. Note that previous FIA reports for other states (e.g., Crocker et al. [2017], Lister et al. [2017]) also describe these methods.

What is a forest?

The FIA program defines forest land as land that has at least 10 percent canopy cover of live tree species of any size or has had at least 10 percent canopy cover of live tree species in the past, based on the presence of stumps, snags, or other evidence, and not currently developed for nonforest use(s) that prevent normal tree regeneration and succession. The area with trees must be at least 1 acre in size; and roadside, streamside, and shelterbelt strips of trees must be at least 120 feet wide to qualify as forest land. Trees in narrow windbreaks, urban boulevards, orchards, and other nonforest land uses are very valuable too, but are not part of the FIA inventory. However, they were inventoried as part of the Great Plains Tree and Forest Invasives Initiative (GPI) and are described in the Trees Outside Forests section starting on p. 18.

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

From an FIA perspective, there are three types of forest land: timberland, reserved forest land, and other forest land. In the Northern Great Plains, about 89 percent of forest land is timberland, 2 percent is reserved forest land, and 9 percent is other forest land.

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

In the Northern Great Plains States' periodic inventories (1995 and before), only trees occurring on timberland plots were measured. Therefore, we could not report the volume of trees on forest land for those inventories; we could report growth, removals, and mortality only on timberland. Since the implementation of the annual inventory system, which began in the Northern Great Plains States with the 2001-2005 inventory, FIA has been able to report volume on all forest land. With the remeasurement of the same annual inventory plots during 2006-2010, and again during 2011-2015, we can now report growth, removals, and mortality on all forest land.

Where are the forests of the Northern Great Plains and how many trees are in them?

Forest distribution, composition, and structure are greatly influenced by many factors including subsurface geology, topography, soil composition, and climate. The concept of an ecoregion (e.g., Bailey [1995]) integrates these factors in order to group areas that are likely to have similar natural communities. The ecoregion classification system is made up of several levels. At the broadest level, ecoregion domains use climate to identify ecologically uniform areas. Additional levels (e.g., ecoregion divisions, provinces, sections, and subsections) represent successively smaller geographic areas based on similarities in the factors mentioned previously. Ecoregion provinces are an appropriate level to broadly describe the ecology of the Northern Great Plains. The region has four ecoregion provinces (Fig. 1). The vast majority is composed of the Great Plains Steppe, Great Plains-Palouse Dry Steppe, and Prairie Parkland (Temperate) ecoregion provinces. The Black Hills Coniferous Forest province is present in western South Dakota.

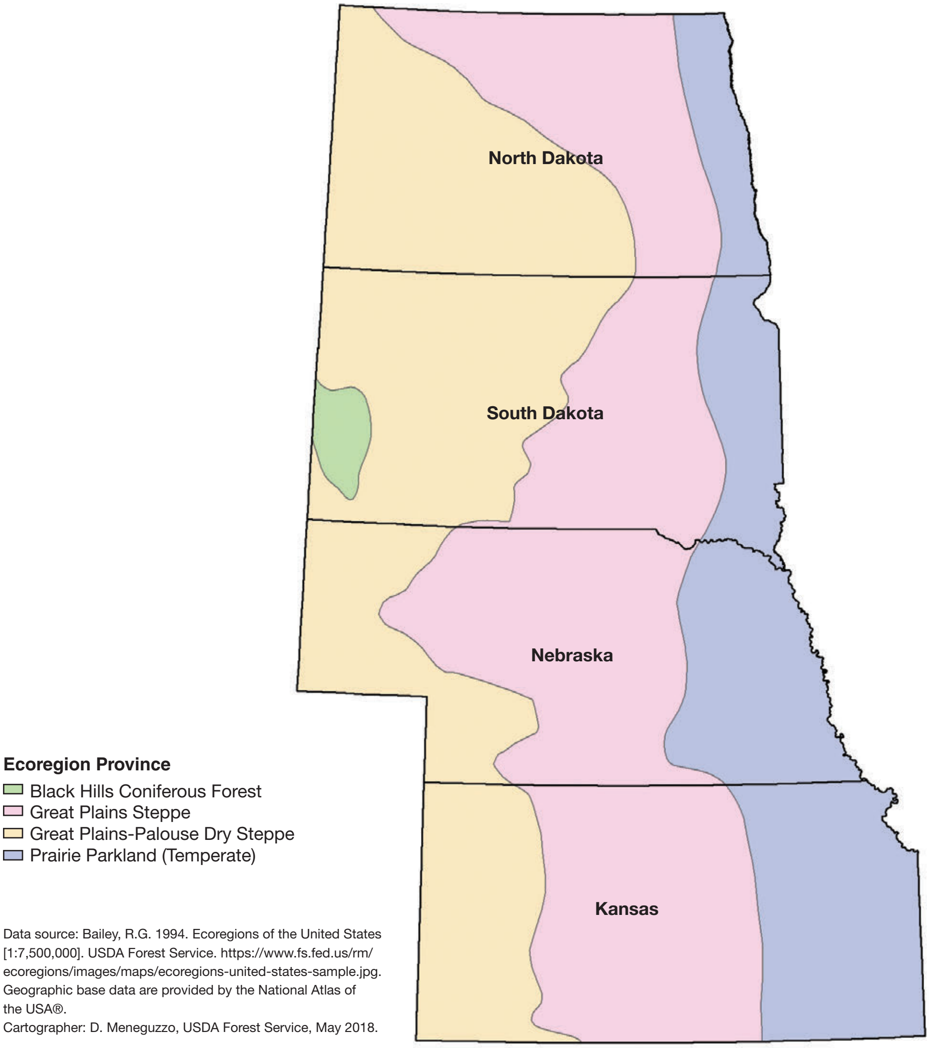


Figure 1.—Ecoregion provinces of Kansas, Nebraska, North Dakota, and South Dakota.

In the Northern Great Plains States, forested areas are generally concentrated along streams and rivers in the east and among the highlands of the west and contain nearly 2.2 billion trees that are at least 1 inch in d.b.h. or diameter at root collar (d.r.c.; measured at the ground line or stem root collar, sometimes used on woodland tree species). We do not know the exact number of trees because the estimate is based on a sample of the total population. Trees were measured on 1,445 forest plots (Fig. 2). Full details of sample design and estimation procedures are available in Bechtold and Patterson (2005).

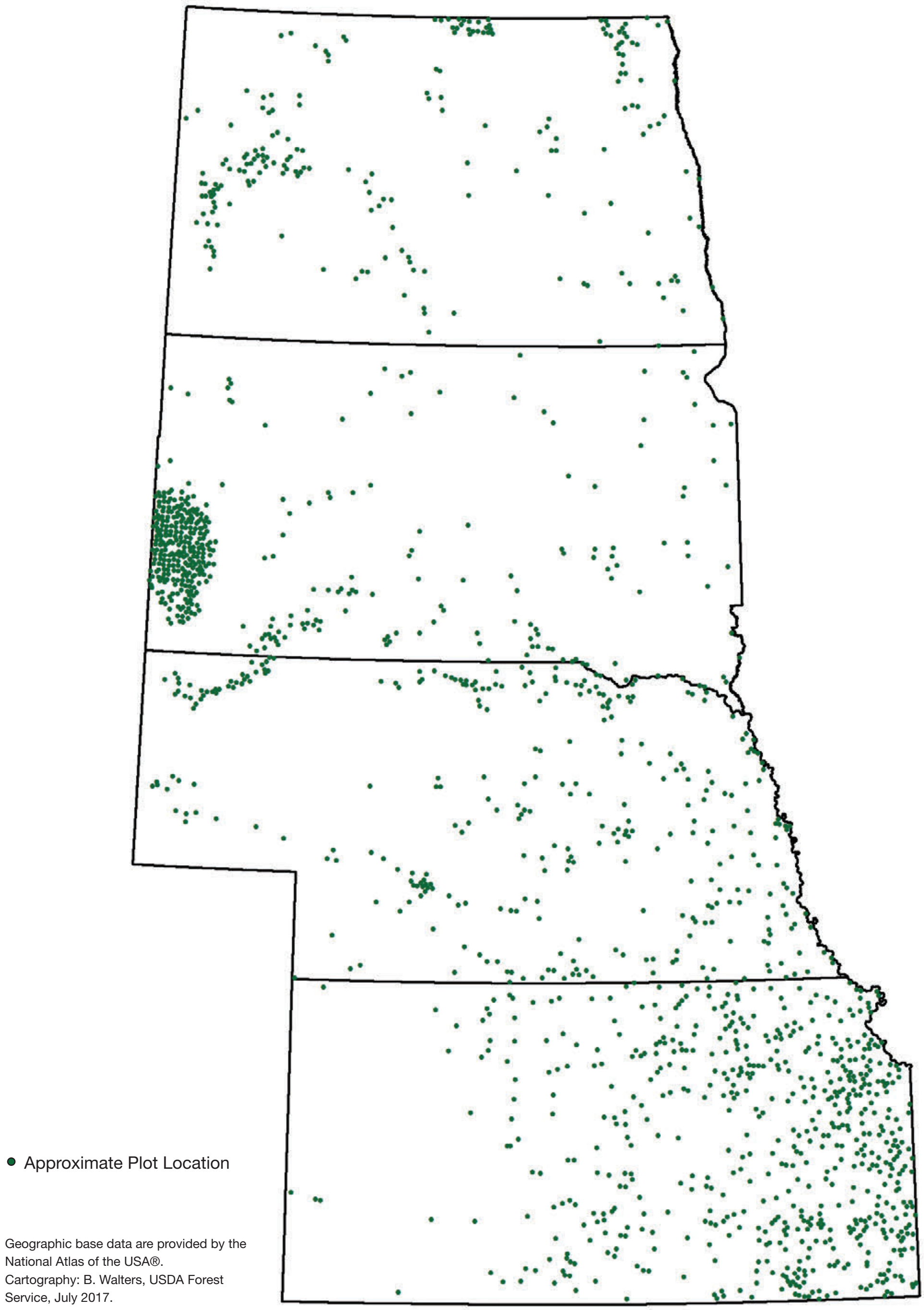


Figure 2.—Distribution of Forest Inventory and Analysis plots that have forest land present, Northern Great Plains States, 2015. Plot locations are approximate.

How do we estimate a tree's volume?

Statistical models are used to estimate tree gross, net, and sound volume based on species, diameter, and merchantable height. Region-specific models were developed by cutting several hundred trees and taking detailed diameter measurements along their length to accurately determine their volumes (Hahn 1984). The comprehensive set of volume equations can be found in Miles and Hill (2010). Tree volumes are reported in cubic feet or board feet, International ¼-inch log scale rule. Board feet volume is also reported in the Scribner log scale rule in this report as it is commonly used in many Plains States. Conversion factors for converting to Scribner board foot scale are also available (Smith 1991).

How much does a tree weigh?

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

How do we estimate all the forest carbon pools?

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

How do we compare data from different inventories?

Data from new inventories are often compared with data from earlier inventories to determine trends in forest resources. For comparisons to be valid, the procedures used in the two inventories must be similar. As a result of ongoing efforts to improve the efficiency and reliability of the inventory, several changes in procedures and definitions have occurred since the inventories of Kansas, Nebraska, North Dakota, and South Dakota during the 1990s. Although these changes will have little effect on statewide estimates of forest area, timber volume, and tree biomass, they may have significant effects on plot classification variables such as forest type and stand-size class. Some of these changes make it inappropriate to directly compare annual inventory (2005, 2010, and 2015) data tables with those published for the 1995 or earlier inventories. Note that references to the periodic inventories each apply to a single year of inventory, but references to the 2015 annual inventory apply to the 5-year period, 2011-2015.

Recently, significant changes were made to the methods for estimating tree-level volume and biomass (dry weight) for northeastern states, and the calculation of change components (net growth, removals, and mortality) was modified for national consistency. Regression models were developed for tree height and percent cull to reduce random variability across datasets.

The component ratio method (CRM) was implemented as a means to obtain biomass estimates for the live aboveground portion of trees, belowground coarse roots, standing dead wood, and down woody debris (Heath et al. 2009). Additionally, the midpoint method introduced some differences in methodology for determining growth, removals, and mortality for a specified sample of trees (Westfall et al. 2009). This approach involves calculating tree size attributes at the midpoint of the inventory cycle (2.5 years for a 5-year cycle) to obtain a better estimate for ingrowth, mortality, and removals. Although the overall net change component is equivalent under the previous and new evaluations, estimates for individual components will be different.

A word of caution on suitability and availability

FIA does not attempt to identify which lands are suitable or available for timber harvesting, particularly because such suitability and availability is subject to changing laws, economic and market constraints, physical conditions, adjacency to human populations, and ownership objectives. The classification of land as timberland does not necessarily mean it is suitable or available for timber production. Forest inventory data alone are inadequate for determining the area of forest land available for timber production. Additional factors, such as those provided, need to be considered when estimating the timber base, and these factors may change with time.

How do we produce maps?

A geographic information system (GIS) and various geospatial datasets were used to produce the maps in this report. Maps were constructed using 1) coloring of counties by category according to forest attributes (such as forest land area), 2) a variation of the k-nearest neighbor (KNN) technique to apply information from forest inventory plots to remotely sensed MODIS imagery (250-meter [820-feet] pixel size) based on the spectral characterization of pixels and additional geospatial information (see Wilson et al. [2012] for more information on this technique), or 3) colored dots to represent plot attributes at approximate plot locations.

Unless otherwise indicated, forest resource data are from FIA; base map layers, such as state and county boundaries were obtained from the National Map (Sugarbaker and Carswell 2011). Depicted FIA plot locations are approximate. Additional FIA data are available at https://www.fia.fs.fed.us/tools-data/. Sources of other geospatial datasets are cited within individual figures. All Northern Great Plains maps are portrayed in Universal Transverse Mercator projection Zone 14 North, North American Datum of 1983.

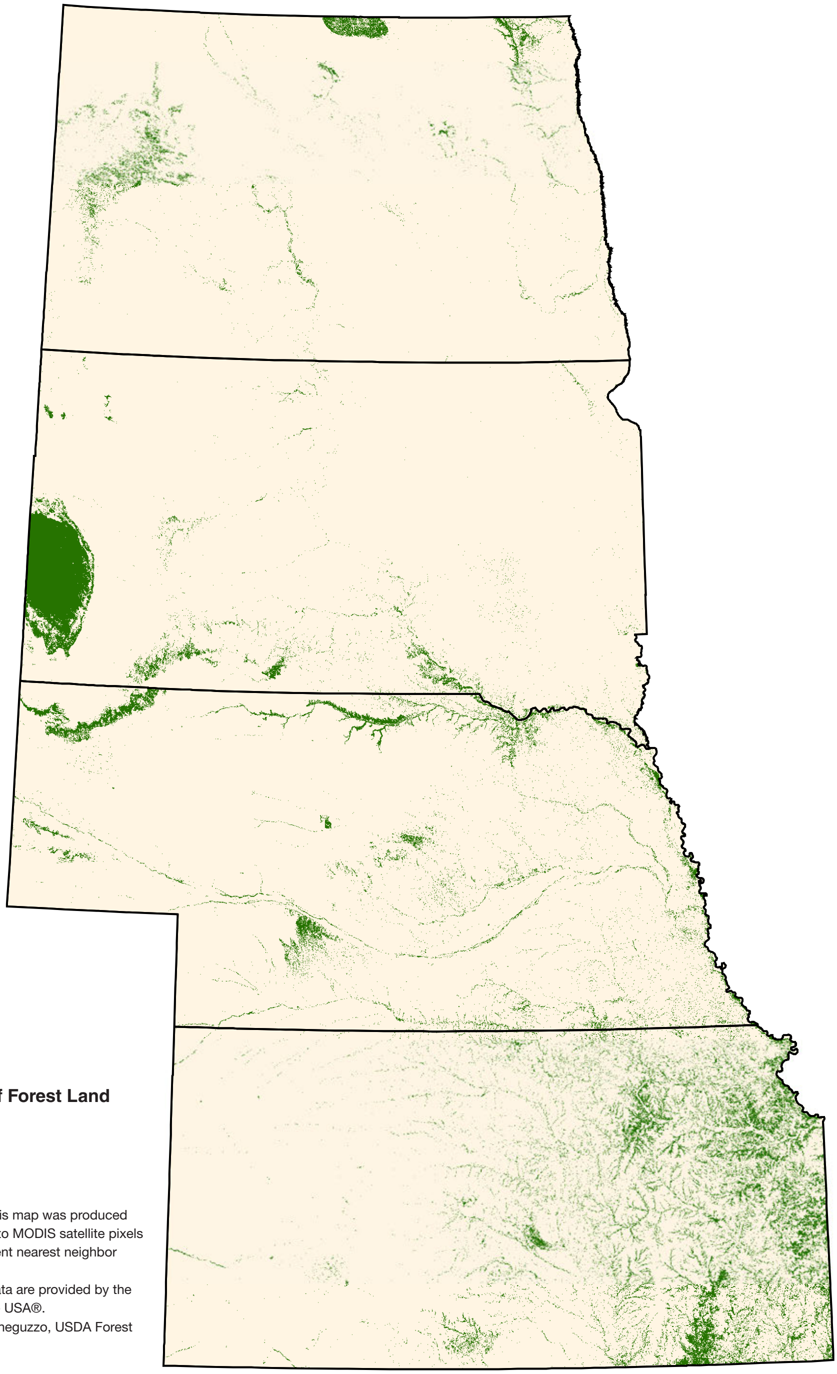
Forest Features

Custer National Forest, South Dakota. Photo by Dacia Meneguzzo, USDA Forest Service.

Forest Area

Background

Measuring forest land area is important for understanding the current status of forest ecosystems as well as trends occurring over time. The Northern Great Plains States are often characterized as prairie or plains due to the topography, soils, limited water supply, and climate, which promote perennial grasses and forbs and limit the natural distribution of forest land. Although forests cover only 3 percent of the land area, they are an extremely important component of the landscape. Forests are found scattered across the region in windbreaks, in wood lots, along streams and rivers, throughout the Black Hills area, and within wooded draws of the western region. The distribution of forest land varies throughout the Northern Great Plains region (Fig. 3). Assessing changes in the forest land base is critical because these may be signs of important changes in land use or forest health conditions.



Processing note: This map was produced by linking plot data to MODIS satellite pixels (250 m) using gradient nearest neighbor techniques.
Geographic base data are provided by the National Atlas of the USA®.
Cartography: D. Meneguzzo, USDA Forest Service, May 2018.

Figure 3.—Distribution of forest land, Northern Great Plains States, 2009.

What we found

The Northern Great Plains forest land area is currently estimated at 6.8 million acres. Forest land has increased by almost 200,000 acres, or 3 percent, since 2010 (Figs. 4 and 5). About 89 percent of the Northern Great Plains forest land is classified as timberland. The area of timberland is estimated at 6.1 million acres, which is an increase of 121,000 acres, or 2 percent since 2010.

What this means

At the regional level, Northern Great Plains forest land area has been gradually increasing since 2005. Although the area of forest land is small compared to the entire land area of the Northern Great Plains, it is an important resource for multiple uses and provides economic and ecological benefits. Whether or not the trend of increasing forest land continues depends on many different factors, such as agricultural practices, commodity prices, and expansion of eastern redcedar. (Common and scientific names of trees are found in Appendix 1.)

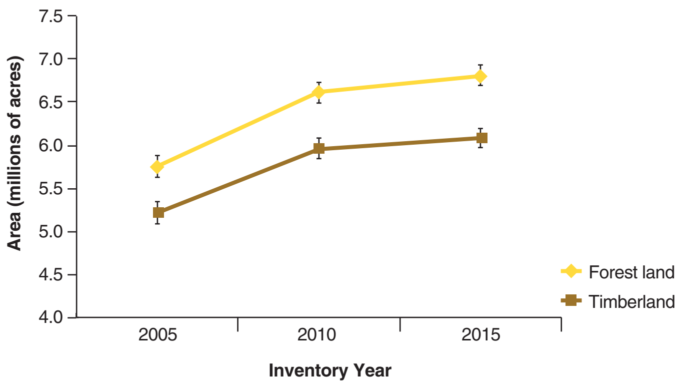


Figure 4.—Area of forest land and timberland by inventory year, Northern Great Plains States. Error bars show a 68 percent confidence interval around the mean.

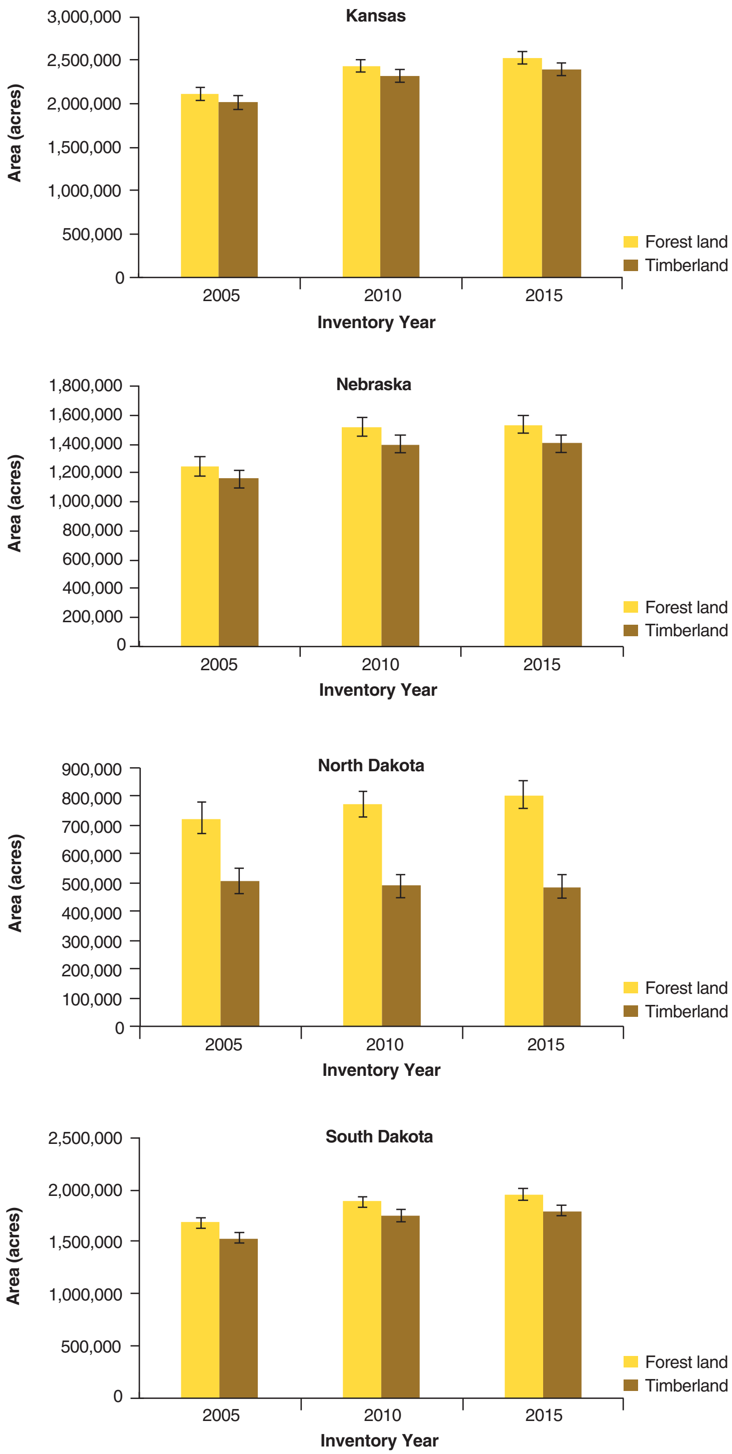


Figure 5.—Area of forest land and timberland by State and inventory year. Error bars show a 68 percent confidence interval around the mean.

Forest Type Distribution

Background

The Northern Great Plains are unique in that the forest types found in the region occur at the geographic limits of many eastern and western forest types of the United States. Forest types are a classification of forest land based on the predominant species, or group of species, present. For example, forest land classified as the eastern redcedar forest type is occupied primarily by eastern redcedar trees. But other tree species, such as gray birch, red maple, sweet birch, Virginia pine, shortleaf pine, or oaks can also be associated with this type. Distributions of forest types are largely determined by geology and climate.

What we found

There are an estimated 6.8 million acres of forest land in the Northern Great Plains States and 79 percent (5.4 million acres) of that total area is occupied by 10 forest types. The remaining forest types make up 16 percent of forest land area while 5 percent of forest lands are nonstocked. The ponderosa pine forest type is the dominant forest type, accounting for nearly 1.4 million acres (20 percent) of forest land area within the region (Fig. 6). The ponderosa pine forest type is found in the southwestern corner of North Dakota and western portions of South Dakota and Nebraska, with a large majority of the type found in the Black Hills of South Dakota.

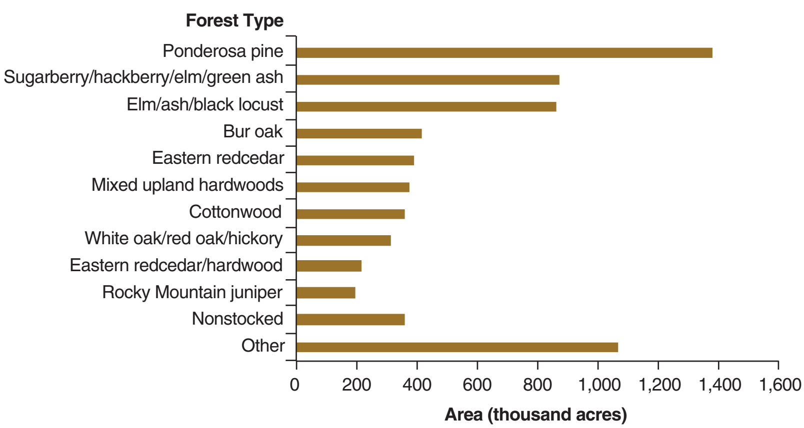


Figure 6.—Area of forest land by the 10 forest types covering the most area, Northern Great Plains States, 2015. The “other” type includes all forest types other than these 10. “Nonstocked” areas are not assigned a specific forest type.

The sugarberry/hackberry/elm/green ash and the elm/ash/black locust forest types each occupy 13 percent of all forest land throughout the Northern Great Plains States. Kansas, however, contains the majority (61 and 66 percent, respectively) of both forest types. The remaining seven forest types and nonstocked lands occupy similar proportions of total forest land area, ranging from 3 to 6 percent each. Between 2005 and 2015, the elm/ash/black locust, sugarberry/hackberry/elm/green ash, and eastern redcedar forest types showed the largest increases in area (Fig. 7). Nonstocked land area also increased. The area of the eastern redcedar and eastern redcedar/hardwood forest types nearly doubled between 2005 and 2015.

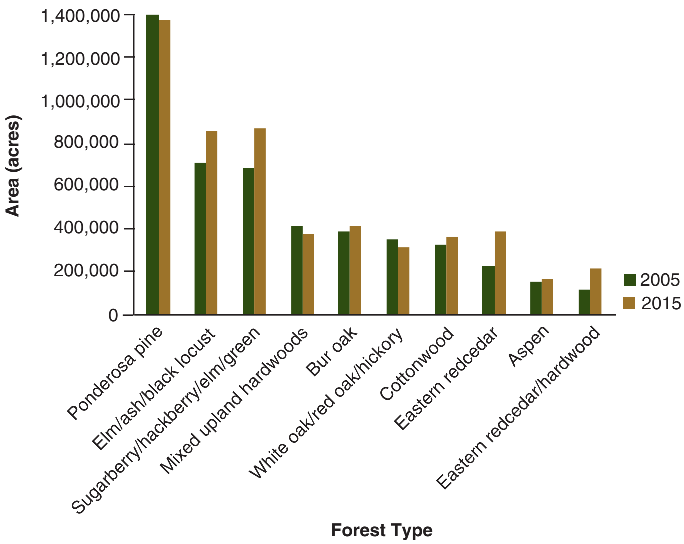


Figure 7.—Forest land area by forest type and inventory year, Northern Great Plains States.

What this means

Site characteristics, land use activities, and the ability of species to adapt to changing conditions have influenced the distribution of forest types throughout the Northern Great Plains. Severe weather-related events, such as drought and wildfire, may also affect future spatial patterns of forest types. Currently, hardwood forest types dominate the forest landscapes, accounting for 70 percent of all forest land across the four States. Softwood forest types, primarily the ponderosa pine, eastern redcedar, and Rocky Mountain juniper forest types, account for 29 percent of the Northern Great Plains States forest land. The large increases in the eastern redcedar and the eastern redcedar/hardwood forest types may indicate that gains in forest land are due to eastern redcedar expansion (e.g., see Meneguzzo and Liknes [2015]). This is an issue to watch because eastern redcedar can outcompete and displace other native tree species, resulting in decreased biodiversity.

Trees Outside Forests

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. Much of the tree cover in the Great Plains, however, is configured in a way that does not meet these requirements (e.g., narrow linear strips). Despite their small size, 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, and protecting structures and livestock from harsh weather. Recently, natural resource agencies have recognized the lack of available information on this important resource, referred to as "trees outside forests" (TOF).

Forest Service assessments of forest health have identified several concerns, including flood damage, ice storms, invasive species encroachment, and various insects and plant diseases (USDA Forest Service n.d.) that threaten tree and forest resources in the Northern Great Plains States. Of particular concern is the spread of the emerald ash borer (*Agrilus planipennis*; EAB), which has been found throughout much of the north-central and eastern portions of the United States and as far north as Quebec and Ontario, Canada (see the Emerald Ash Borer section on p. 58 for more information).

In response to these concerns, State forestry agencies in the Great Plains States, with funding assistance from the Forest Service's State & Private Forestry, began a project called the Great Plains Tree and Forest Invasives Initiative (GPI) (Lister et al. 2011, Meneguzzo et al. 2018). Objectives of the GPI include an inventory of the TOF resource, identification of EAB mitigation needs and utilization opportunities, and development of educational materials to help land managers and landowners cope with potential EAB impacts (Nebraska Forest Service 2007). To meet the first objective, FIA's National Inventory and Monitoring Applications Center (NIMAC) helped design the inventory, process the data, and create a reporting tool to quantify and characterize the TOF resource as a supplement to the information FIA already collects in forested areas. Data were collected in 2008 and 2009 on urban and rural field plots with trees present but not classified as forest land. Note that the definition of "urban" used in the GPI study was a minor modification to the U.S. Census Bureau's urban places definition (U.S. Census Bureau 1994), which includes places with at least 2,500 inhabitants. There can thus be large natural areas surrounding some of the smaller population centers designated by the U.S. Census Bureau as urban places.

What we found

Results from the GPI inventory indicate that the TOF resource consists of nearly 458 million trees. This resource occupies 5.1 million acres, which is roughly almost as much area as the 6.4 million acres of defined forest land estimated for 2009 (based on the FIA forest land area estimate corresponding to the last year of the GPI survey) (Fig. 8). More than half of TOF acreage (56 percent) is associated with agriculture (Fig. 9).

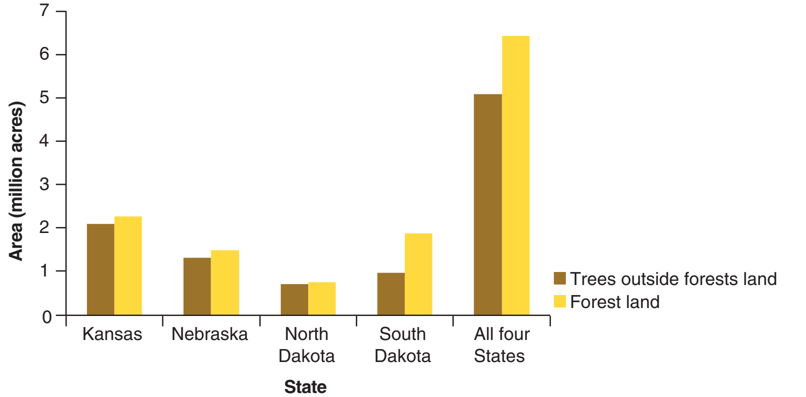


Figure 8.—FIA forest land area and TOF land area estimates for individual Northern Great Plains States, and the four States combined, 2008-2009.

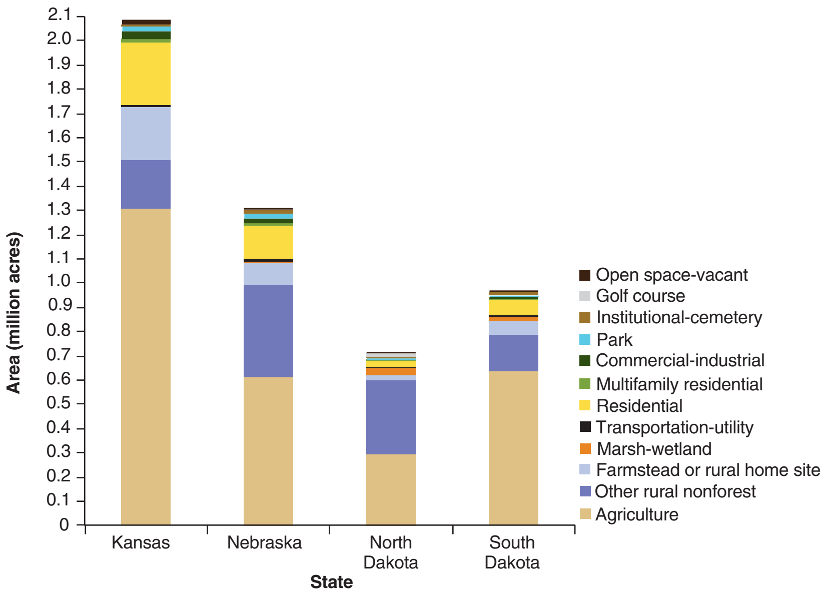


Figure 9.—Area of trees outside forests by land use, as classified by the Great Plains Tree and Forest Invasives Initiative (Lister et al. 2011), by Northern Great Plains State, 2008-2009.

The species compositions of the forest and TOF areas are very different. For example, ponderosa pine is a key component of forest land areas but not nonforested areas with trees. Nonnative species, primarily Siberian elm and Russian olive, are more prevalent in TOF areas. Overall, ash species are the most numerous TOF species in the region (Fig. 10), especially in North Dakota and South Dakota (Fig. 11).

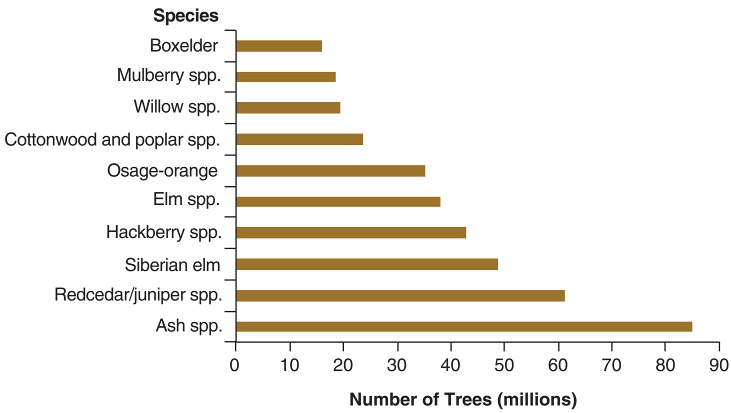


Figure 10.—Ten most prevalent species of trees on land outside forests in the four Northern Great Plains States combined, 2008-2009.

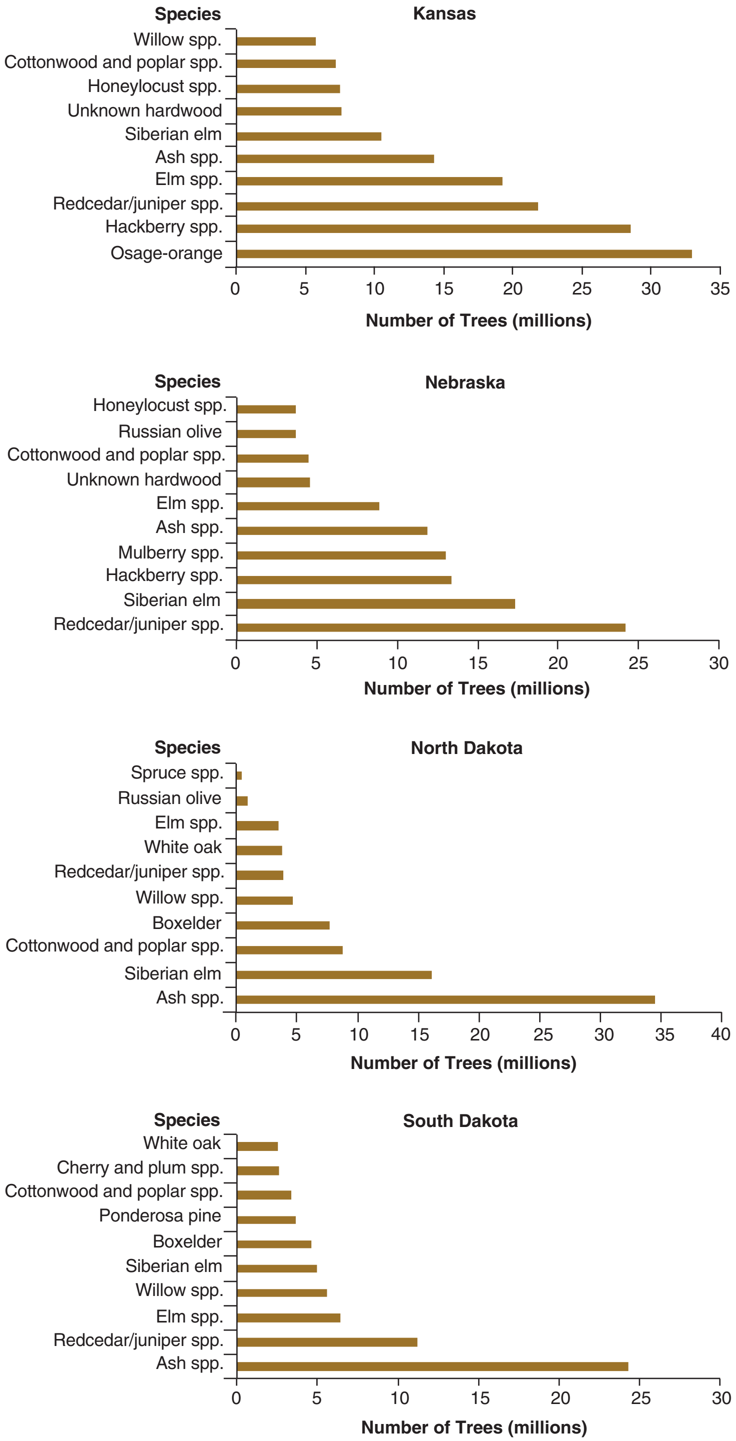


Figure 11.—Ten most prevalent species of trees outside forests by number, by Northern Great Plains State, 2008-2009.

In the four-State region, most (92 percent) of the TOF resource occurs on privately owned lands. Osage-orange, eastern redcedar, and ash are the most prevalent species on private lands. Elm, ash, and ponderosa pine are the most common TOF species on publicly owned TOF lands.

Windbreaks, which are linear tree plantings that serve distinct purposes on the landscape, are a very important TOF feature. Windbreaks occur on more than 1.8 million acres, or 36 percent, of all TOF lands in the region, but windbreak occurrence varies widely by state (Fig. 12). For example, windbreaks are found on less than one-fourth (21 percent) of all TOF lands in Kansas but on more than half (62 percent) of TOF lands in North Dakota.

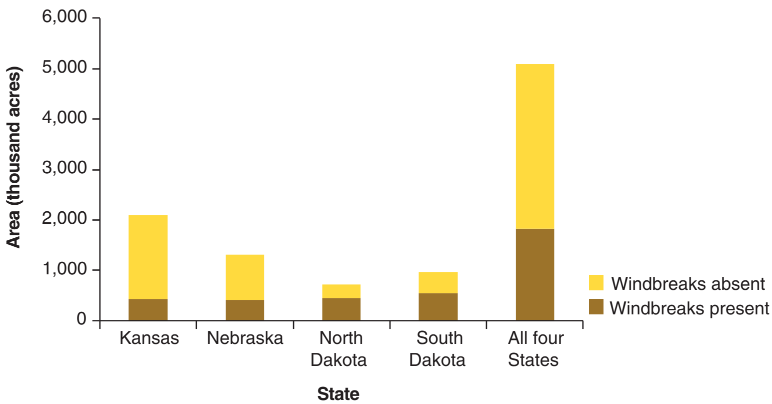


Figure 12.—Area of trees outside forests by windbreak presence or absence, by Northern Great Plains State, 2008-2009.

Windbreaks serve a variety of functions on TOF lands in the region (Fig. 13). Not all functions were found in all states, and the area of TOF by function varies by state as well (Fig. 14). Nebraska was the only state where planted riparian buffers were observed, and South Dakota was the only state where recorded TOF served as living snowfences. Kansas had no TOF on abandoned farmsteads. North Dakota had no TOF whose primary function was wildlife habitat.

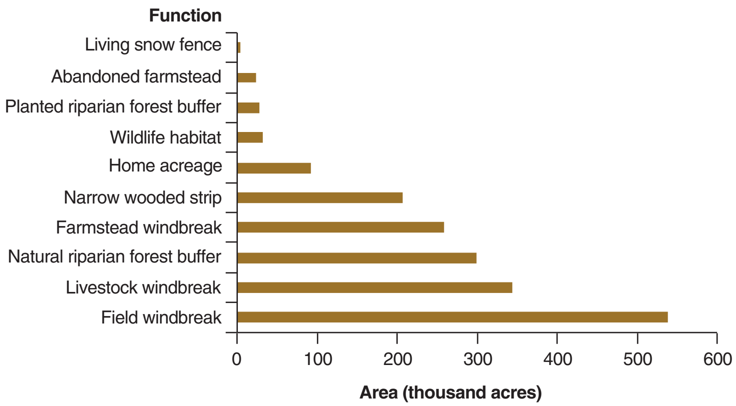


Figure 13.—Primary function of windbreaks by area, Northern Great Plains States, 2008-2009.

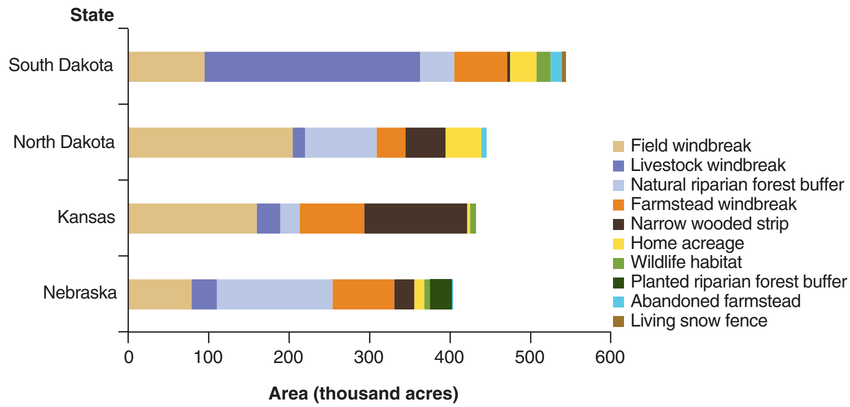


Figure 14.—Primary functions of windbreaks by area and Northern Great Plains State, 2008-2009.

What this means

The Northern Great Plains region contains a substantial area of lands with trees that do not meet FIA's definition of forest land but are nonetheless an important resource. It is essential that these areas continue to be monitored and protected because they are vital for protecting soil, wildlife, domestic animals, homes, roads, water sources, and recreational areas. The results obtained from the GPI provide useful information for the careful management of the TOF resource and of the ecosystem services these trees provide. For example, the data can be used to promote wise windbreak stewardship, which may include monitoring for EAB infestation, removing dead or dying trees, and replacing them with nonsusceptible species. In addition, a clear understanding of differences in urban and rural tree species composition can help guide managers in their efforts to design sustainable landscapes that offer multiple benefits, such as wildlife habitat, windbreak functions, energy savings, and forest product development.

Differences in relative abundance of nonnative and potentially invasive species between forested and TOF areas are not too surprising because fragmented areas often have higher proportions of nonnative or invasive species, the latter of which can include native species that exhibit invasive behavior. In addition, TOF areas often contain artificially regenerated (i.e., planted) tree species that are selected for their adaptability and ability to grow under a variety of environmental conditions. The higher prevalence of eastern redcedar, Siberian elm, and Russian olive in TOF areas compared to forest land supports this generalization. Although these species are useful for conservation trees, for example, when planted in windbreaks, it is important that they be monitored because they can tolerate conditions where other species struggle to grow and thereby can easily displace native vegetation.

Public Forest Ownership

Background

Forest ownership has a profound impact on how land is managed. Public forest lands provide an array of opportunities including forest products, outdoor recreation, and outdoor education programs. They also play an important role in providing clean water and wildlife habitat.

What we found

More than one-fourth (26 percent or 1.8 million acres) of the Northern Great Plains States' 6.8 million acres of forest land is publicly owned. The USDA Forest Service administers most of the public forest land: 17 percent of the total area of forest land, or an estimated 1.2 million acres. State and local government agencies are stewards of 5 percent of the total area, or an estimated 301,000 acres; the remaining public land is owned by various Federal agencies (Fig. 15). The distribution of forest land ownership varies by state (Fig. 16). A large portion of Federal land is concentrated in the western part of Nebraska, North Dakota, and South Dakota, particularly in the Black Hills National Forest in South Dakota (Fig. 17). Seventy-four percent of the region's forest land is privately owned.

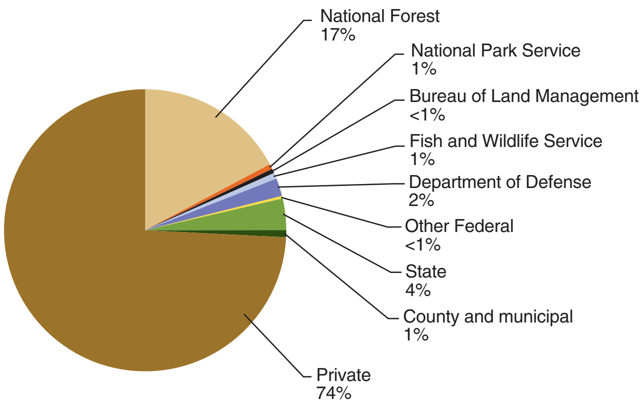


Figure 15.—Proportion of forest land by ownership or administering government unit, Northern Great Plains States, 2015.

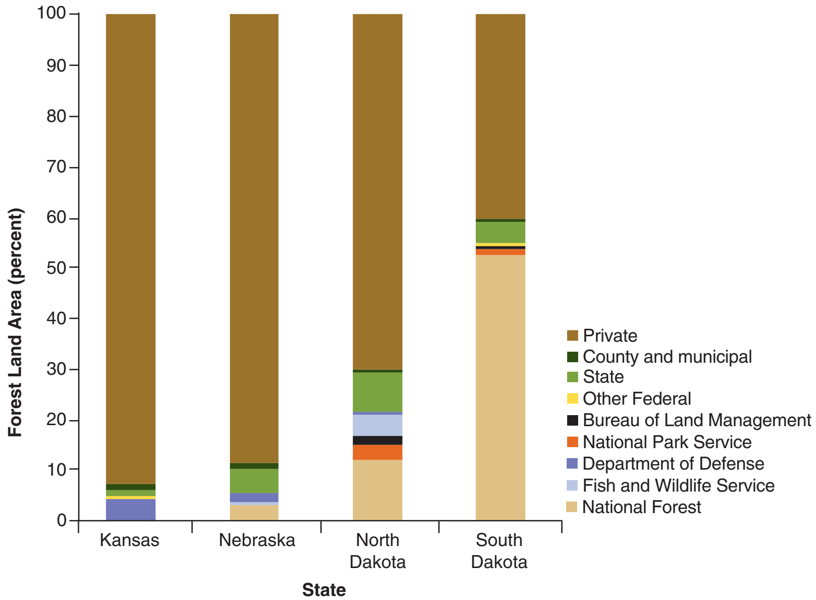


Figure 16.—Proportion of forest land by ownership or administering government unit and Northern Great Plains State, 2015.

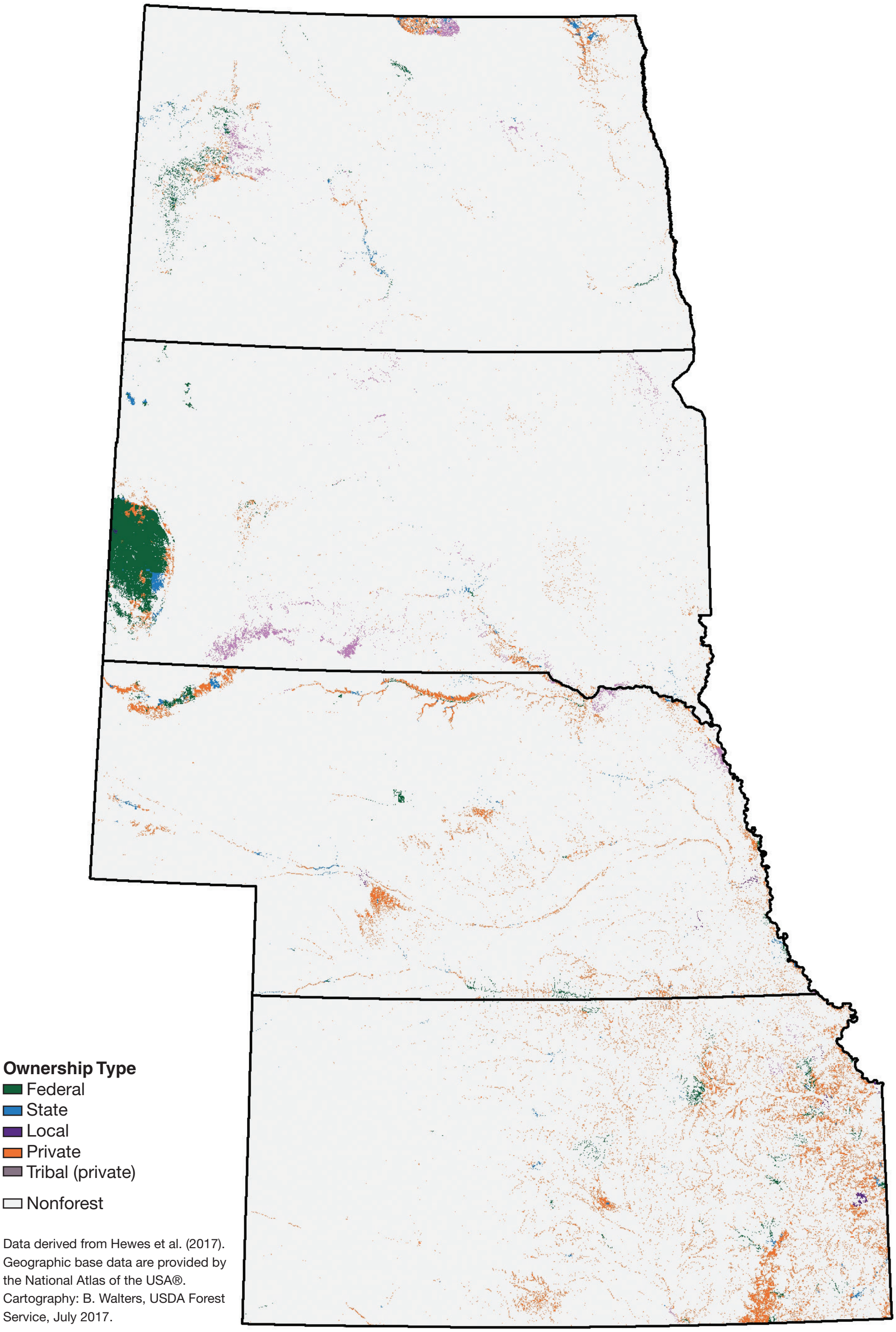


Figure 17.—Distribution of forest land by ownership, Northern Great Plains States.

What this means

Forest management objectives vary by owner. Publicly owned forests are often managed for multiple benefits including water quality, forest products, wildlife, and recreation. Several Federal agencies manage areas available for cattle grazing, harvesting of forest products, and recreation, such as hiking, camping, bird watching, and fishing. Privately owned forests are managed based on the owners' objectives. Private landowners hold nearly 5.1 million acres of forest land, and their continued involvement in forest management across the region is important to the future of forests in the Great Plains.

Family Forest Ownership

Background

How privately owned forest land is managed is primarily the owner's decision. Therefore, to a large extent, private landowners determine the availability and quality of forest resources, such as recreational opportunities, timber, and wildlife habitat. By understanding the priorities of forest landowners, leaders of the forest conservation community can better help owners meet their needs, and in so doing, help conserve the States' forests for future generations. The National Woodland Owner Survey (NWOS), conducted by FIA, studies private forest landowners' attitudes, management objectives, and concerns. It focuses on the diverse and dynamic group of owners that is the least understood—families, individuals, and other unincorporated groups, collectively referred to as "family forest owners." The NWOS data reported here are based on the responses from 224 family forest ownerships from Kansas, Nebraska, North Dakota, and South Dakota, which participated between 2011 and 2013.

What we found

Nearly three-fourths of the forest land across the Northern Great Plains is privately owned (Fig. 18). The vast majority of this land, an estimated 4.5 million acres, is held by family forest owners. Corporations own an estimated 150,000 acres. Other private owners, including conservation organizations, unincorporated clubs and partnerships, and Native American tribes, own an additional estimated 450,000 acres.

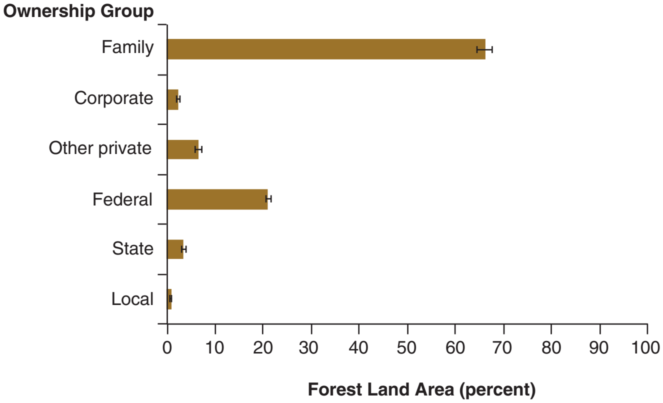


Figure 18.—Proportion of forest land by ownership group, Northern Great Plains States, 2013. Error bars show a 68 percent confidence interval around the mean.

According to the NWOS, there are an estimated 93,000 family forest ownerships across the Northern Great Plains that each own at least 10 acres of forest land. The average forest holding size of this group is 46 acres; 77 percent of these family forest owners have less than 50 acres of forest land, but 67 percent of the family forest land is in holdings of at least 50 acres (Fig. 19). The primary reasons for owning forest land are related to wildlife, aesthetics, nature protection, family legacy, and water protection (Fig. 20). The most common activities on family forest land are personal recreation, such as hunting and hiking, followed by livestock grazing, control of invasive species, and cutting trees for personal use, such as firewood (Fig. 21). Most family forest ownerships have not participated in traditional forest management and

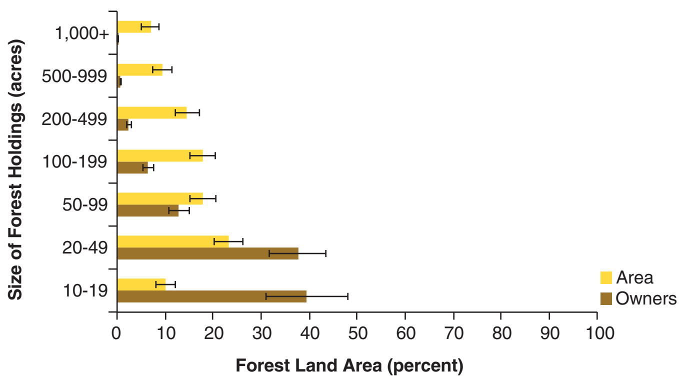


Figure 19.—Proportion of family forest ownerships and acres of forest land by size of forest land holdings, Northern Great Plains States, 2013. Error bars show a 68 percent confidence interval around the mean.

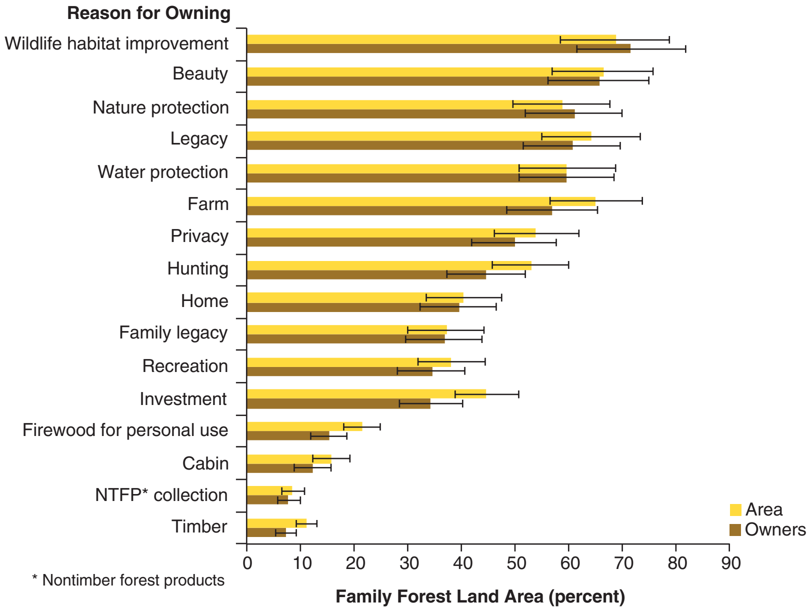


Figure 20.—Proportion of family forest ownerships and acres of forest land by reasons given for owning forest land ranked as very important or important, Northern Great Plains States, 2013. Categories are not exclusive. Error bars show a 68 percent confidence interval around the mean.

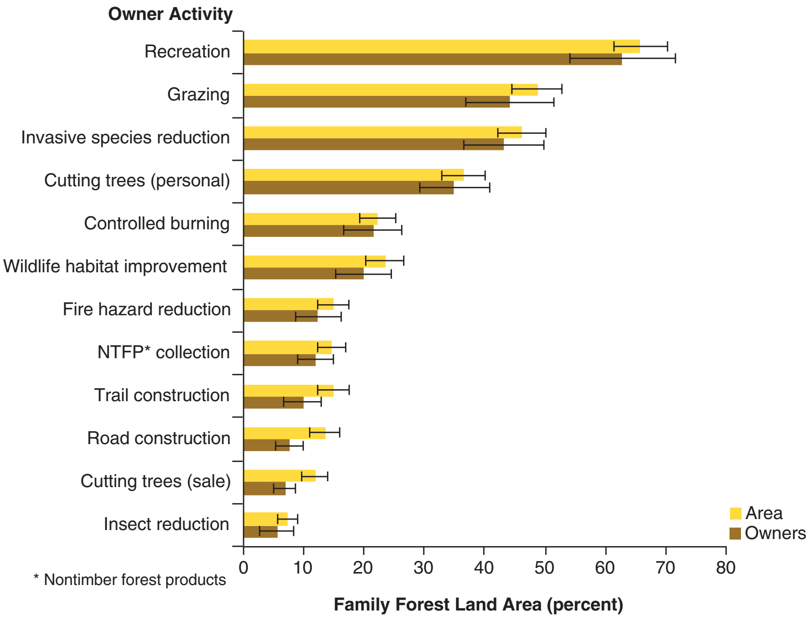


Figure 21.—Percentage of family forest ownerships and acres of forest land by activities in the past 5 years, Northern Great Plains States, 2013. Categories are not exclusive. Error bars show a 68 percent confidence interval around the mean.

assistance programs in the past 5 years (Fig. 22). The most commonly used program is the forestry cost-share program, but fewer than 20 percent of the ownerships have participated in it. The average age of family forest owners across the Northern Great Plains is 65 years; 49 percent of the family forest land is owned by people who are at least 65 years of age (Fig. 23).

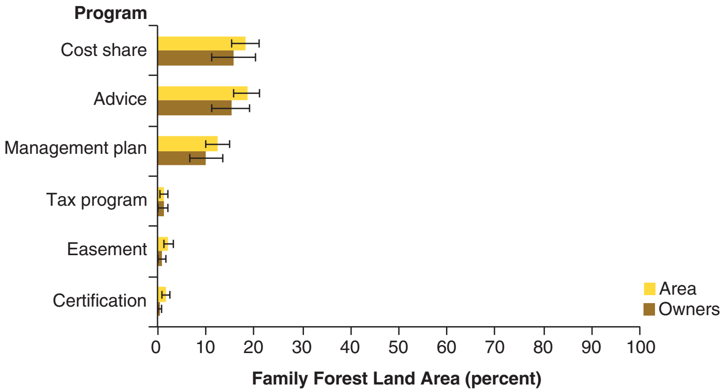


Figure 22.—Proportion of family forest ownerships and acres of forest land by participation in forest management programs, Northern Great Plains States, 2013. Categories are not exclusive. Error bars show a 68 percent confidence interval around the mean.

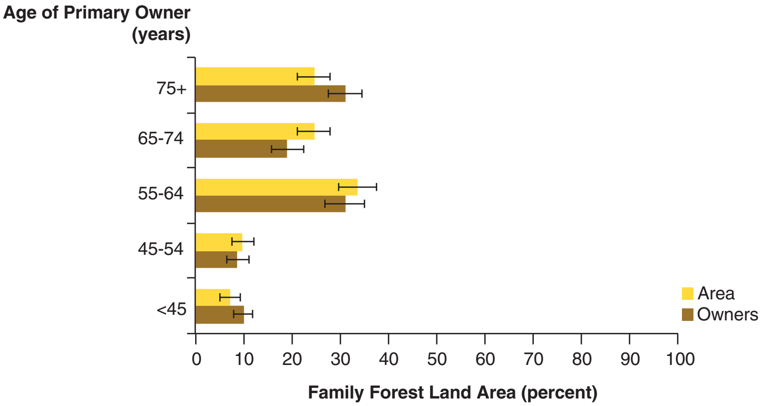


Figure 23.—Proportion of family forest ownerships and acres of forest land by age of primary owner, Northern Great Plains States, 2013. Error bars show a 68 percent confidence interval around the mean.

What this means

The future of the forests lies primarily in the hands of those who own and control the land. It is therefore critical to understand forest owners and what policies and programs can help them conserve the forests for current and future generations.

The fate of family forest land is arguably the most uncertain. Although family forest owners own their land primarily for amenity reasons, many owners are actively doing things with their land. Yet more than 60 percent of them do not have a management plan and have not participated in most other traditional forest management planning or assistance programs. There are significant opportunities to help these owners increase their engagement with and stewardship of their lands. Programs such as Tools for Engaging Landowners Effectively (http://www.engaginglandowners.org) can help the conservation community develop and implement programs more effectively and efficiently. Another important trend to watch is the aging of the family forest owners. The relatively advanced age of many of the owners portends the passing on of many acres of land to the next generation in the not-too-distant future. To help owners meet their bequest goals, programs are available, such as Your Land Your Legacy (http://masswoods.net/monthly-update/your-land-your-legacy-deciding-future-your-land) and Ties to the Land (http://tiestotheland.org). But it is uncertain who the future forest owners will be and what they will do with their land.

Forest Biomass

Background

Biomass is the aboveground total dry weight of all live components of forest trees, including stumps, boles, limbs, and tops but excluding foliage and roots. Estimates of total biomass and its distribution among stand components provide an indication of forest health trends and the sustainability of forest management practices. These estimates also provide important information for analyzing carbon sequestration and for determining the amount of wood or fiber available for fuel. Traditionally, timber harvests have been measured in board feet or cubic feet. Increasingly they are measured in green tons or dry tons. In the Northern Great Plains the ratio of green tons to dry tons is approximately 1.9 to 1.0.

What we found

The average aboveground dry weight of a tree in the Northern Great Plains region increases dramatically with increasing tree diameter (Table 1). Trees in the 7.0- to 8.9-inch diameter size class, for example, weigh slightly more than twice the trees in the 5.0- to 6.9-inch class.

Table 1.—Average aboveground tree biomass by diameter class and major species group, Northern Great Plains States, 2015

Diameter class	Softwoods	Hardwoods
Inches	-------------- *Dry pounds*	-----------
1.0-2.9	4.1	7.8
3.0-4.9	23.7	48.6
5.0-6.9	62.7	119.9
7.0-8.9	156.1	243.5
9.0-10.9	303.8	432.2
11.0-12.9	507.6	679.9
13.0-14.9	769.7	1,008.1
15.0-16.9	1,104.4	1,400.5
17.0-18.9	1,516.4	1,853.9
19.0-20.9	1,991.8	2,431.1
21.0-28.9	3,027.0	3,644.4
29.0+	1,655.4	8,160.6

Biomass, measured as all live aboveground tree biomass on forest land, was estimated at about 201 million dry tons in 2015, an increase of 10.5 million dry tons since 2010. In 2015 there was an average of 29.6 dry tons of live aboveground tree biomass per acre of forest land, which is an increase of about 0.7 tons per acre since 2010. The distribution of forest biomass varies across the Northern Great Plains States; Kansas and Nebraska have substantially higher average aboveground biomass per acre than North Dakota or South Dakota (Table 2). Some of the highest aboveground biomass per acre is found in western South Dakota, northwestern Nebraska, and eastern Kansas (Fig. 24).

Table 2.—Average aboveground tree biomass on forest land for selected States and the conterminous United States, 2015

Geographic area	Dry tons per acre
United States Lower 48	41.7
Northern Great Plains (Kansas, Nebraska, North Dakota, South Dakota)	29.6
Kansas	35.7
Nebraska	30.8
North Dakota	24.4
South Dakota	23.0
Iowa	42.2
Missouri	42.1
Montana	29.9
Minnesota	28.7
Colorado	26.9
Wyoming	24.4

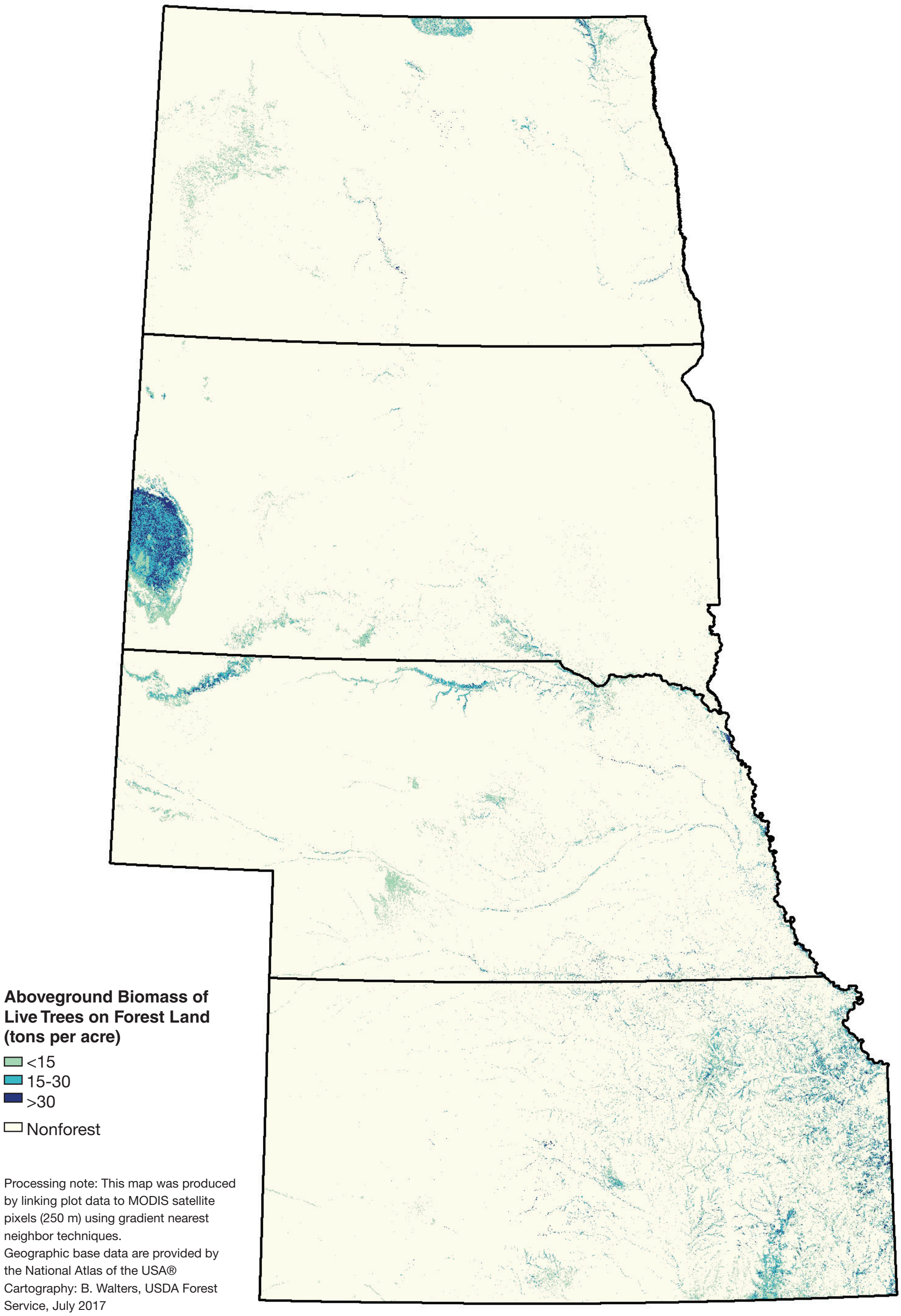


Figure 24.—Distribution of aboveground live-tree biomass on forest land, Northern Great Plains States, 2009.

In 2015, most (94 percent) of the total live-tree aboveground biomass on forest land was contained in trees 5.0 inches d.b.h. or larger, and saplings (trees less than 5.0 inches d.b.h.) made up the remaining 6 percent (Fig. 25). Boles alone accounted for nearly three-fourths (74 percent) of total biomass and most (76 percent) of the total live-tree aboveground biomass was composed of hardwood species. The total live-tree aboveground dry biomass on timberland in 2015 was 188 million tons, a 5 percent increase from the 178 million tons reported in 2010 and a 17 percent increase from the 161 million tons reported in 2005.

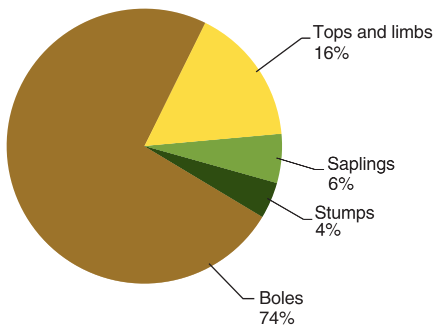


Figure 25.—Proportion of aboveground live-tree biomass on forest land by tree component, Northern Great Plains States, 2015.

What this means

The Northern Great Plains are continuing to gain aboveground live-tree biomass due primarily to increases in forest land area. However, with the development of systems that utilize wood as an energy source for heating, demand for woody biomass across the region is expected to increase. Continued adjustments to planning and management strategies will be needed as the demand for biomass energy changes.

Carbon Stocks

Background

Carbon accumulates in growing trees via the photosynthetically driven production of structural and energy-containing organic (carbon) compounds that primarily accumulate in trees as wood. Over time, this stored carbon also accumulates in dead trees, woody debris, litter, and forest soils. For most forests, the understory grasses, forbs, and nonvascular plants as well as animals represent minor pools of carbon stocks. 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 can be lost from a forest stand through mechanisms such as respiration (including live trees and decomposers), combustion, runoff or leaching of dissolved or particulate organic particles, or direct removal such as the harvest and utilization of wood. From the perspective of reporting greenhouse gases, 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—i.e., nonliving plant material), and soil organic matter exclusive of coarse roots and estimated to a depth of 1 meter (39 inches). Estimates are organized by ecosystem pool, and are based on sampling and modeling. The level of information available for making the carbon estimates varies among pools; for example, the greatest confidence is in the estimate of live-tree carbon because of the level of sampling and availability of allometric relationships applied to the tree data. Live-tree biomass is estimated according to the component ratio method described in Woodall et al. (2011) with the foliage component following Jenkins et al. (2003). Carbon in standing dead trees is based on Domke et al. (2011). Estimates for the additional carbon pools—understory vegetation, down dead wood, forest floor litter, and soil organic carbon—are taken directly from the Forest Inventory and Analysis database condition table (O'Connell et al. 2015). Limited data and high variability are associated with lower confidence in the soil organic carbon estimates, thus limiting interpretation of these estimates.

What we found

Total forest ecosystem carbon stocks in the Northern Great Plains States are estimated to be 397 million tons of carbon: 164 million tons in Kansas, 91 million tons in Nebraska, 46 million tons in North Dakota, and 96 million tons in South Dakota. Overall, this represents a 4 percent increase for the region relative to 5 years ago.

Live trees and forest soils contain the largest average relative proportions of total forest carbon within the Northern Great Plains States forest ecosystems. Live trees (including saplings) account for 32 percent of forest carbon stocks, and current estimated soil organic carbon accounts for 54 percent of forest ecosystem carbon. Nineteen percent of carbon is in the wood and bark of the boles of trees at least 5 inches d.b.h. (Fig. 26). These proportions vary across the region and by forest-type group.

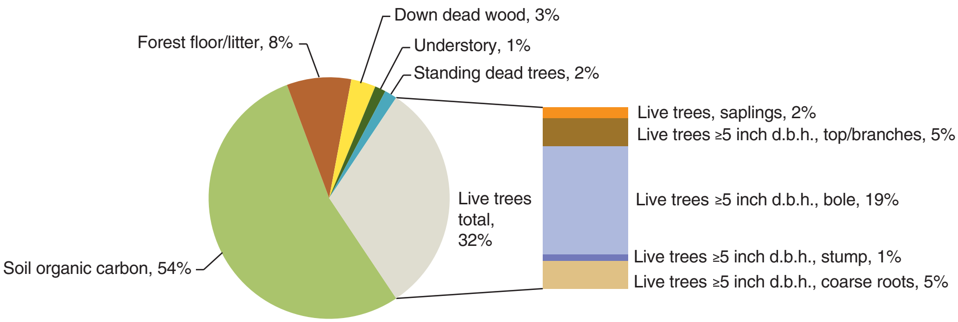


Figure 26.—Proportion of total forest carbon stocks within each forest ecosystem component, Northern Great Plains States, 2015. Note that live-tree carbon (32 percent of total carbon stock) is subdivided into live saplings (at least 1 inch but less than 5 inches d.b.h., 2 percent of total live trees) and trees at least 5 inches d.b.h. (30 percent of total live trees, which is further divided into four components).

Species composition can affect carbon stocks and the relative distribution among pools. This variability is illustrated by pooling the average tons of carbon per acre according to forest-type group and four classifications: biomass (live trees and understory), dead wood (standing dead trees and down dead wood), litter, and soil (Fig. 27). This figure includes only those forest-type groups that account for at least 1 percent of forest carbon within any of the four Northern Great Plains States. Note that the sometimes considerable variability among forest-type groups is most closely associated with variability in biomass (which is essentially live trees; see Figure 26). Carbon density (tons per acre) is greatest in the elm/ash/cottonwood and oak/hickory forest-type groups. These two forest-type groups also contain the most forest area, so they have the largest total carbon stocks (tons of carbon per acre times area within each forest-type group), representing 65 percent of total forest carbon in the Northern Great Plains States. Carbon density generally increases with stand age, and this net accumulation is greater for aboveground living biomass (live trees and understory) versus nonliving carbon pools (standing dead, down dead, and litter) (Fig. 28). However, in terms of total aboveground carbon stocks, more than half (53 percent) are represented by the 41- to 80-year age classes whereas the youngest age class accounts for only 5 percent of forest carbon stocks.

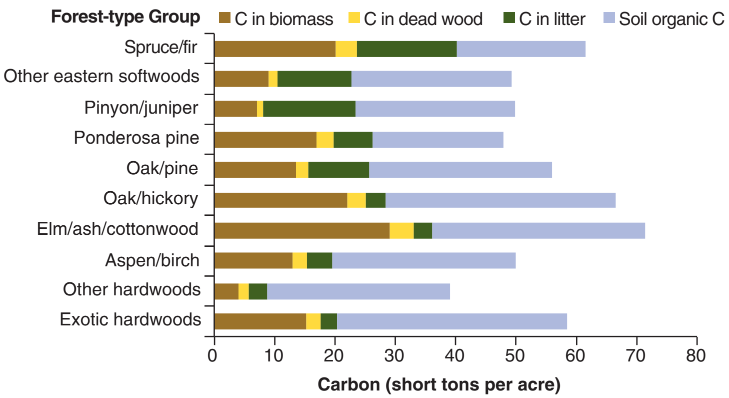


Figure 27.—Average carbon stocks per acre on forest land by forest type or forest-type group according to four classifications: biomass (live trees and understory), dead wood (standing dead trees and down dead wood), litter, and soil, Northern Great Plains States, 2015.

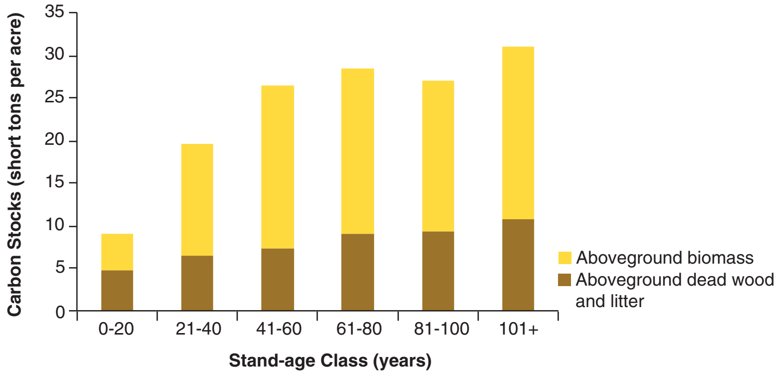


Figure 28.—Carbon per acre by stand-age class for aboveground living plant biomass (live trees at least 1 inch d.b.h. and understory) versus dead wood (standing dead and down dead) and litter pools, Northern Great Plains States, 2015.

Carbon summaries provided here reflect average values over all forest land. Actual stocks for a particular stand will depend on a combination of influences—site history, management, stand age, or component species, for example—so individual sites may vary from the summaries provided in Figure 26, 27, or 28. As an example, the regionwide average carbon per acre for live trees is 28 tons carbon per acre for stands that are identified as fully stocked, but the site-to-site variability is such that 50 percent of measured plots fell between 19 and 37 tons carbon per acre, with greater carbon per acre in 25 percent of the remaining stands and lower levels of carbon in the remaining 25 percent of stands.

The current carbon estimation methods and data were also applied to the 2010 forest inventories (data not shown) to produce summaries that could be compared with those for the 2015 inventories. Overall forest carbon per acre increased by 1.0 percent relative to 5 years ago, and live-tree carbon per acre values increased by 2.3 percent. Total forest area increased by 3.0 percent over the same period so that total carbon stocks in 2015 are 4.0 percent greater than the corresponding values calculated for 2010. The 5-year total carbon stock increases, by state, are 5.7 percent in Kansas, 2.3 percent in Nebraska, 4.7 percent in North Dakota, and 2.7 percent in South Dakota.

What this means

Forest carbon stocks or differences in stock broadly reflect other measures of forest resources such as stand age, volume, or stocking. However, these summaries are useful as a reference highlighting the region relative to published regional or national forest carbon reports. The principal results of these carbon summaries are: 1) Most of the carbon is in organic carbon in forest soils, followed by live trees; 2) the majority of carbon is in stands 41-80 years old; 3) specific stand-level carbon varies; and 4) overall, carbon stored in forests has increased over the past 5 years.

Tree Species Composition

Background

The dynamics of the growth, development, and ecosystem function of a forest stand depend largely on species composition. Changing conditions such as management practices, recreational activities, wildfire, extreme weather events, and invasive species determine which tree species are present in forests and their abundance. Monitoring changes in species composition provides important information for effective forest management and acts as an indicator of forest health, growth, and succession. Assessing forest ecosystems with respect to species composition measures provides information on current and potential forest conditions.

What we found

In the Northern Great Plains States, there are an estimated 2.2 billion trees (at least 1.0 inch d.b.h.) on forest land, or an average of 318 trees per acre, of which 205 are saplings (i.e., trees at least 1.0 inch d.b.h. and less than 5.0 inches d.b.h.) and 113 are trees 5.0 inches d.b.h. or larger. Saplings make up most (64 percent) of the total number of trees growing on forest land. Poletimber-size trees (5.0 to 9.0 inches d.b.h. for softwoods; 5.0 to 11.0 inches d.b.h. for hardwoods) account for 24 percent of the trees, and sawtimber-size trees account for the remaining 11 percent. County-level summaries of sapling and tree densities are shown in Figures 29 and 30, respectively.

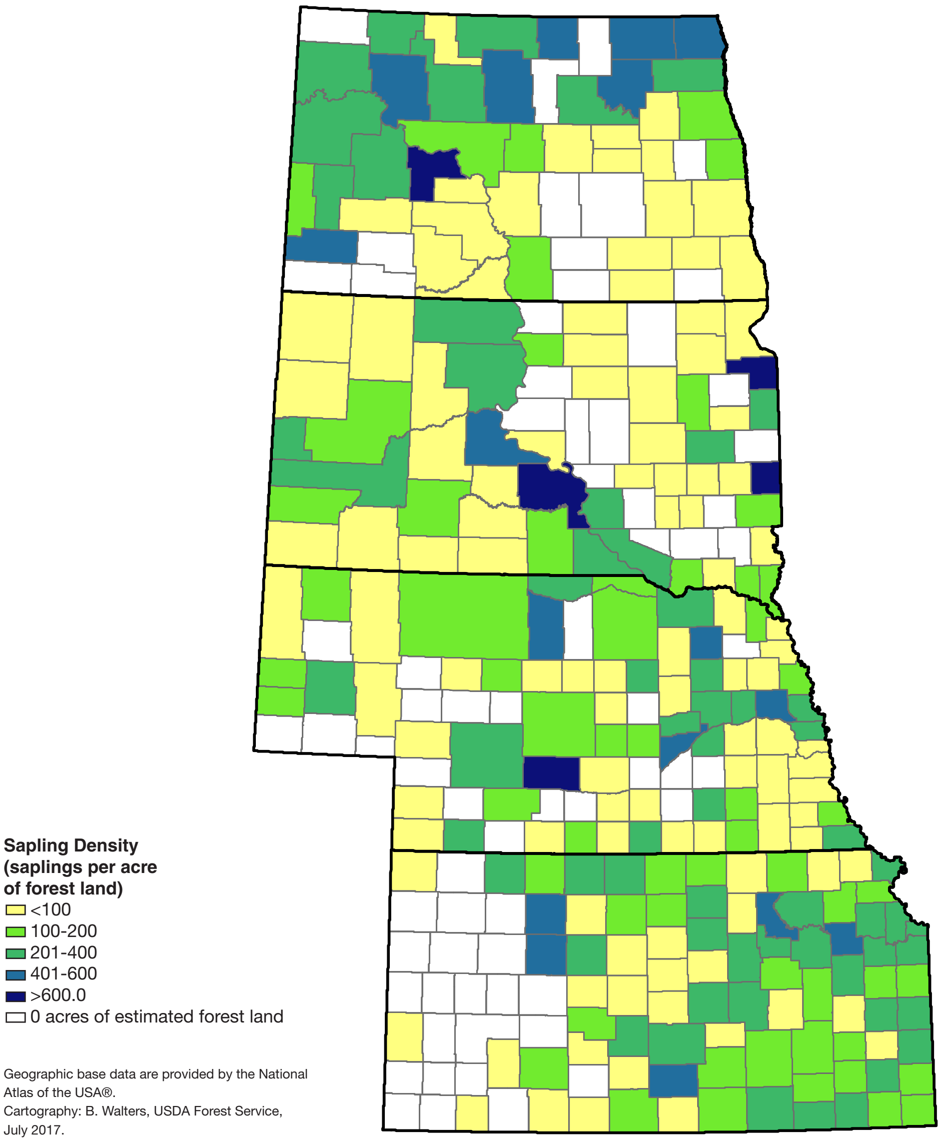


Figure 29.—Density of saplings (trees at least 1 inch but less than 5 inches d.b.h.) on forest land by county, Northern Great Plains States, 2015.

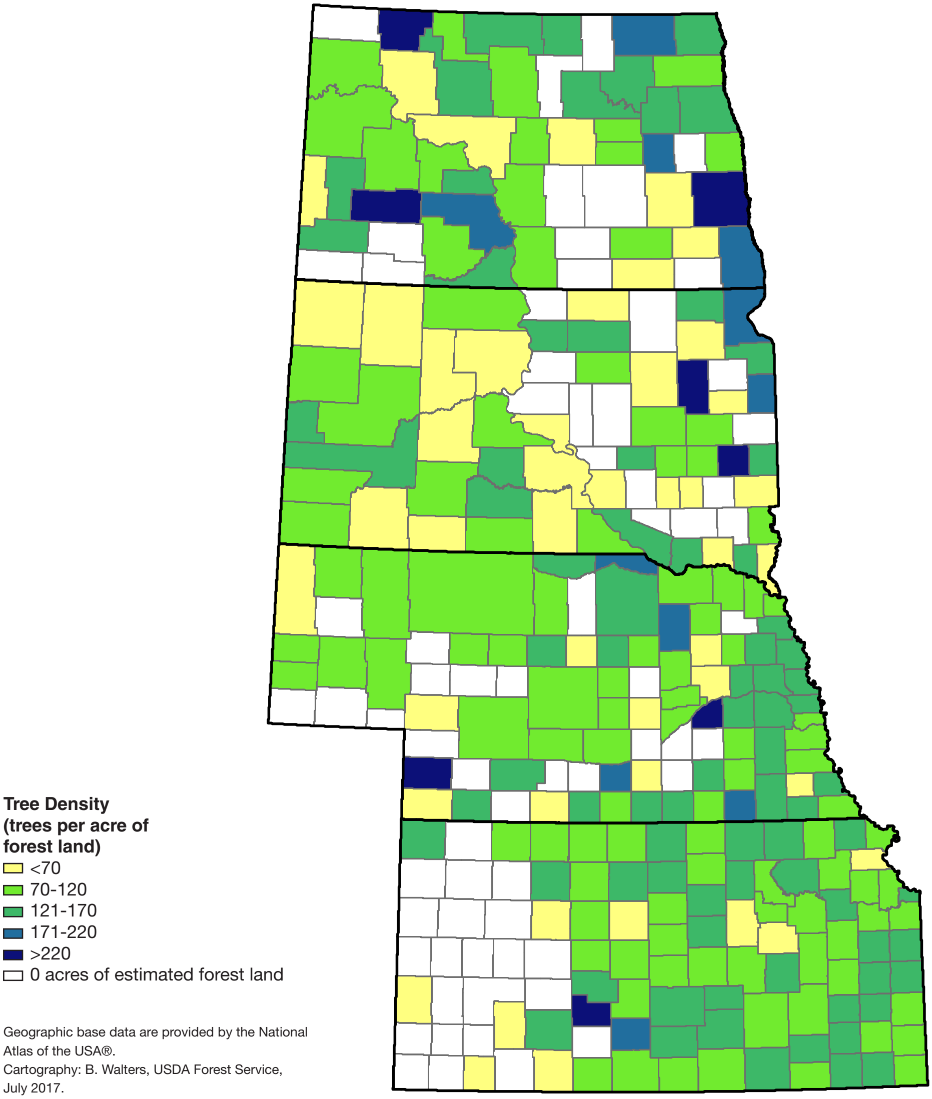


Figure 30.—Density of trees (at least 5 inches d.b.h.) on forest land by county, Northern Great Plains States, 2015.

Between 2010 and 2015, the total number of trees on forest land increased by 93.9 million or 4.3 percent. Saplings increased by 5.5 percent, and poletimber-size trees and sawtimber-size trees increased by 2.1 and 4.7 percent, respectively (Fig. 31). Ponderosa pine was by far the most numerous species found on forest land across the region with more than 405 million trees in 2015 (Fig. 32), or 19 percent of all trees. Eastern redcedar, green ash, hackberry, and American elm round out the five most numerous species found on forest land across the Northern Great Plains States. In Kansas, hackberry is the most common tree species (Fig. 33). Eastern redcedar, green ash, and ponderosa pine are the most common in Nebraska, North Dakota, and South Dakota, respectively (Fig. 33). The sapling-size class had the most species undergoing a decrease in numbers between 2010 and 2015 (Table 3). Of all species, Rocky Mountain juniper and eastern redcedar had the largest increases by percentage change in the sawtimber- and poletimber-size classes. Ponderosa pine is the most numerous species in all size classes despite decreases in the poletimber- and sawtimber-size classes. Ponderosa pine saplings had the largest increase of all species in terms of number of trees between 2010 and 2015.

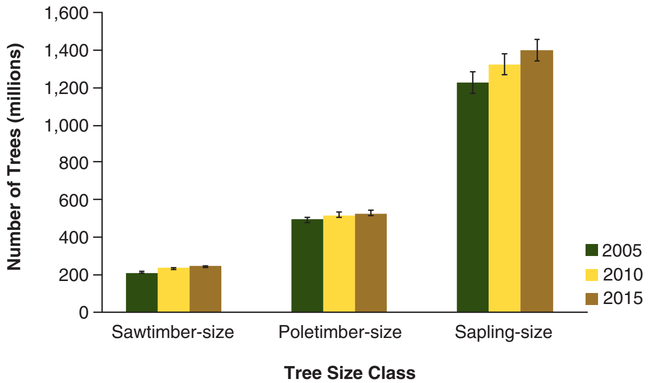


Figure 31.—Number of all live trees by tree size class on forest land, Northern Great Plains States, 2015. Error bars show a 68 percent confidence interval around the mean.

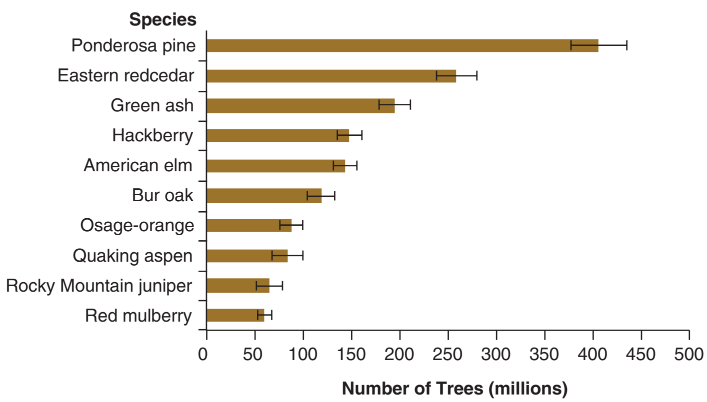


Figure 32.—Most abundant tree species on forest land by number, Northern Great Plains States, 2015. Error bars show a 68 percent confidence interval around the mean.

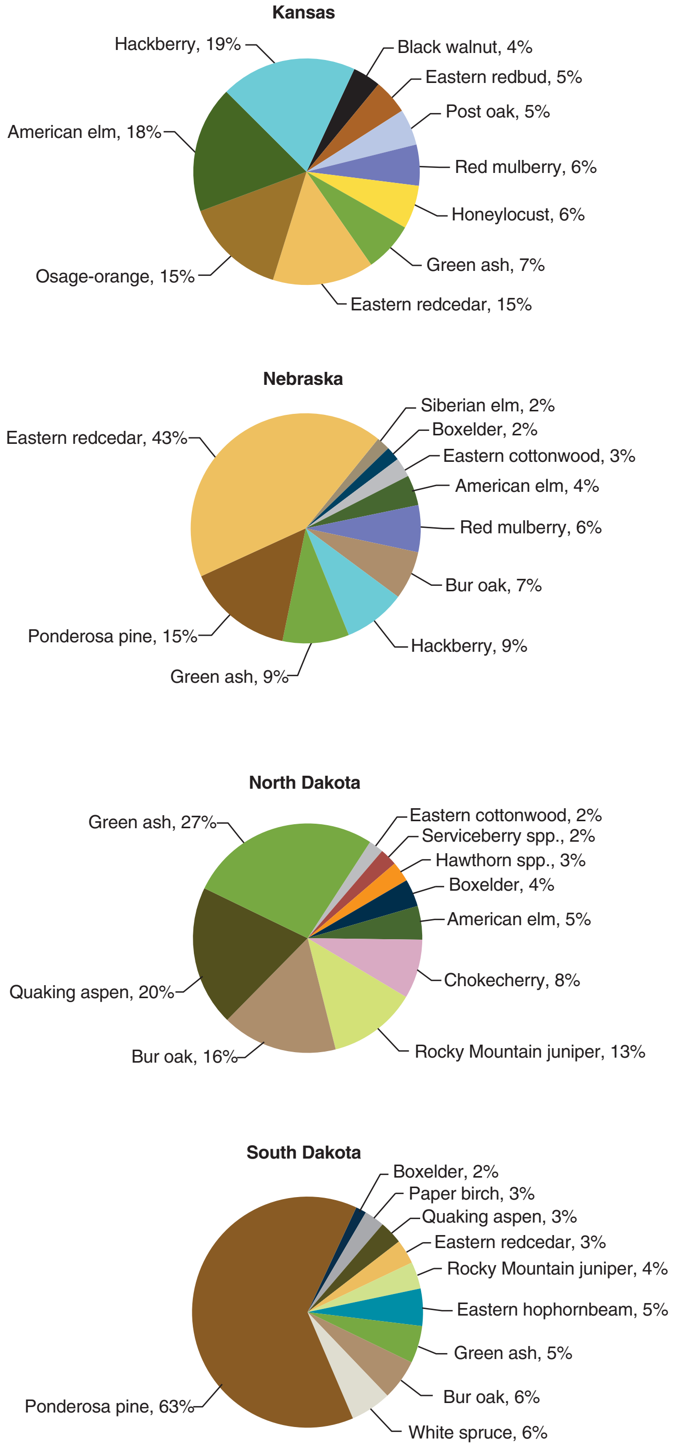


Figure 33.—Most abundant live tree species on forest land by percentage by Northern Great Plains State, 2015.

Table 3.—Tree species by size class with the largest increase or decrease in the number of trees between the 2010 and 2015 inventories, Northern Great Plains States

Population Change	Species	Percent Change	Number of trees, 2010 (thousands)	Number of trees, 2015 (thousands)
	Sawtimber			
Increase				
	Rocky Mountain juniper	24	7,276	9,021
	Eastern redcedar	24	14,901	18,507
	Hackberry	3	12,849	13,257
	Green ash	6	15,279	16,156
	Osage-orange	10	5,224	5,725
	Red mulberry	22	5,943	7,250
	Quaking aspen	7	1,749	1,878
	Bur oak	11	15,979	17,658
	American elm	7	8,421	9,033
	Eastern cottonwood	3	14,837	15,255
Decrease				
	Ponderosa pine	-5	87,189	82,485
	Black willow	-22	2,191	1,702
	Poletimber			
Increase				
	Rocky Mountain juniper	23	12,620	15,550
	Eastern redcedar	17	43,620	50,838
	Hackberry	14	30,399	34,534
	Green ash	0	55,253	55,298
	Osage-orange	2	30,399	31,049
	Red mulberry	8	19,188	20,715
	Quaking aspen	7	15,927	17,064
Decrease				
	Ponderosa pine	-7	93,276	86,682
	Black willow	-5	2,790	2,660
	Bur oak	-7	50,261	46,966
	American elm	-1	42,516	42,036
	Sapling			
Increase				
	Rocky Mountain juniper	19	33,604	40,043
	Eastern redcedar	12	169,061	189,638
	Hackberry	36	73,758	100,204
	Bur oak	1	53,570	53,933
	Ponderosa pine	14	206,856	236,478
Decrease				
	Black willow	-86	12,893	1,827
	Green ash	-1	125,099	123,352
	Osage-orange	-15	60,136	50,989
	Red mulberry	-13	36,585	31,855
	Quaking aspen	-15	76,494	65,147
	American elm	-13	106,993	92,637
	Eastern cottonwood	-17	6,776	5,607

What this means

Although the total number of live trees increased by only 4 percent between inventories, there were some notable changes in the species composition. For example, decreases in ponderosa pine sawtimber and poletimber show the continuing effect of mortality due to mountain pine beetle (*Dendroctonus ponderosae*). Decreases in the number of quaking aspen saplings suggest overmature stands. Lack of disturbance, such as fire or harvesting, has resulted in older stands with little natural regeneration. For some species, natural regeneration can be hindered by the lack of processes that promote regeneration, such as flooding, fire, and harvesting. Limited species diversity is an underlying threat to the long-term sustainability of the region's forest resources. The climate and soils of the Northern Great Plains limit the number of tree species that can survive. Forests composed of one or few species often undergo episodes of abrupt decline simply because all trees are vulnerable to the same damaging factors. Similarly, these stands are more susceptible to pest outbreaks in comparison to those that consist of several different (or nonhost) species (North Dakota Forest Service 2010).

Forest Growth

Background

The growth of a forest stand 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 and minus the net volume of trees that became cull trees. Average annual net growth represents an average for the annual change in volume between the two most recent inventories: 2010 and 2015.

What we found

Average annual net growth of live trees (5 inches d.b.h. or larger) on Northern Great Plains States forest land decreased from about 191 million cubic feet per year in 2010 to about 157 million cubic feet in 2015, which is less than the average annual net growth estimate of 170 million cubic feet in 2005. Net growth of softwoods has continually decreased since 2005, whereas net growth of hardwoods increased after 2005 and has since remained stable (Fig. 34).

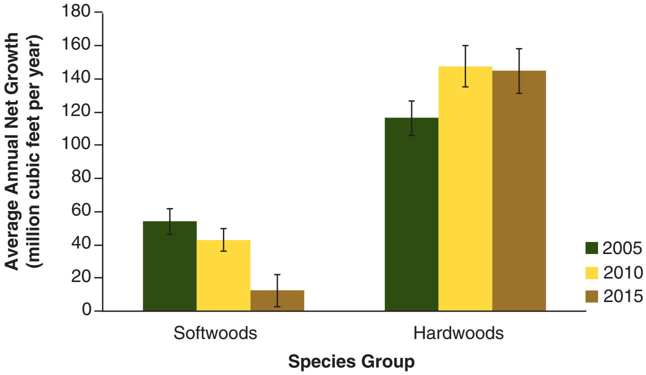


Figure 34.—Average annual net growth by major species group and inventory year, Northern Great Plains States, 2015. Error bars show a 68 percent confidence interval around the mean.

The 10 species with the largest increase in growth volume account for 85 percent of the total growth, compared to 81 percent in the 2010 inventory. Species with notable increases in growth volume since 2010 include eastern redcedar, hackberry, and American elm; cottonwood, bur oak, green ash, and black walnut had decreases. Siberian elm had the highest growth as a percentage of total live-tree volume at 7.3 percent since 2010, and ponderosa pine had the lowest growth rate at -0.6 percent (Fig. 35).

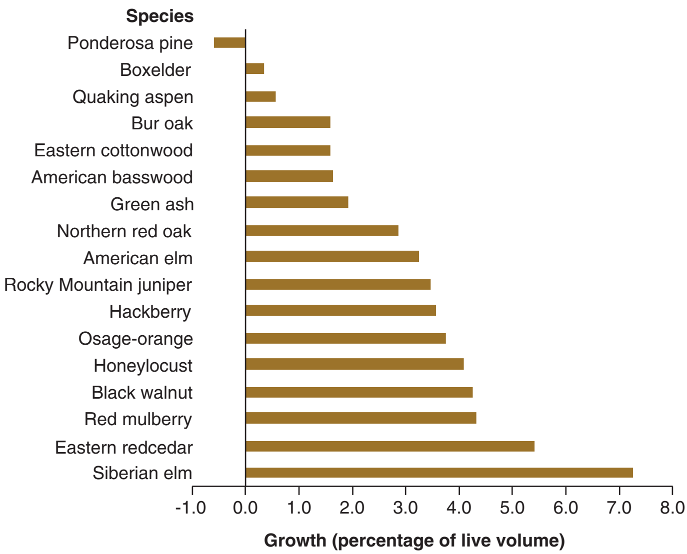


Figure 35.—Average annual net growth of live trees on forest land as a percentage of total live-tree volume for the 17 species with the highest live volume, Northern Great Plains States, 2015.

The average annual net growth of live trees on forest land as a percentage of all live-tree volume varies by landowner group. The rate is negative for the National Park Service (-6.2 percent), Fish and Wildlife Service (-0.8 percent), and the Forest Service (-0.4 percent). The average annual net live-tree growth rate was positive on lands held by local government (3.6 percent), Department of Defense (3.1 percent), and private ownerships (2.4 percent). The average rate was highest for lands held by other Federal agencies: 4.6 percent per year.

What this means

Total net growth decreased between 2010 and 2015, but net growth for most species in the Northern Great Plains States forests is positive, which indicates a generally sustainable resource. The decrease in growth between inventories is primarily due to ponderosa pine mortality. The fact that the 10 species with the largest increase in net growth make up more of the total growth compared to the past inventory is an issue to watch because it may be indicative of less diverse forests in the future.

Although growth rates are useful indicators of sustainability, disturbance trends, species vitality, and direction of succession, growth information provides only one piece of the sustainability puzzle. Information on mortality and removals is also needed to identify the changing composition of the forest. The three change components (growth, mortality, and removals) provide information only on trees 5 inches d.b.h. or larger. As a result, information on the understory component is not reflected in any of these measures.

Mortality

Background

Tree mortality influences the overall health and structure of a forest. It can be caused by any one or a combination of factors, such as insects, disease, adverse weather, succession, competition, or human or animal activities. Tree volume lost as a result of land clearing or harvesting is not included in mortality estimates.

What we found

The average annual mortality on Northern Great Plains States forest land in 2015 was 153.2 million cubic feet, or about 1.8 percent of the 2015 volume. Among the most abundant species by live cubic foot volume, the mortality rate was the highest for boxelder at 5.6 percent and the lowest for northern red oak at 0.3 percent (Fig. 36).

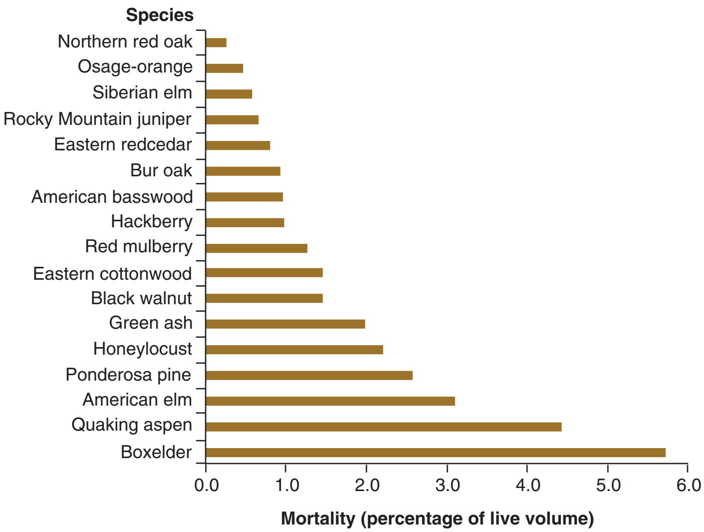


Figure 36.—Average annual mortality on forest land as a percentage of total live-tree volume for the 17 species with the highest live volume, Northern Great Plains States, 2015.

The identifiable primary causes of tree mortality were weather, insects, fire, disease, animals (e.g., browsing by wildlife or livestock grazing that causes mortality), and vegetation (e.g., suppression, competition, vines) (Fig. 37). The cause of mortality could not be determined in nearly one-fourth (24.1 percent) of the cases.

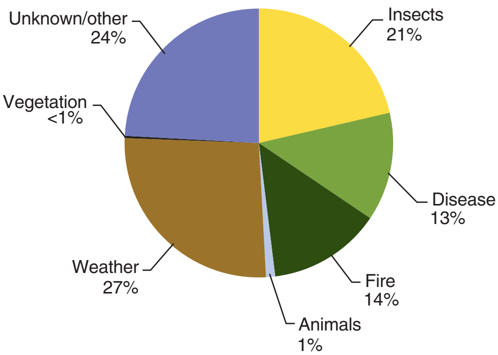


Figure 37.—Proportion of average annual mortality by primary cause on forest land, Northern Great Plains States, 2015.

The mortality rate of live trees on forest land as a percentage of current live-tree volume varies by ownership class (Fig. 38). The rate is highest on National Park Service lands at 8.4 percent, followed by "other Federal" lands at 4.9 percent.

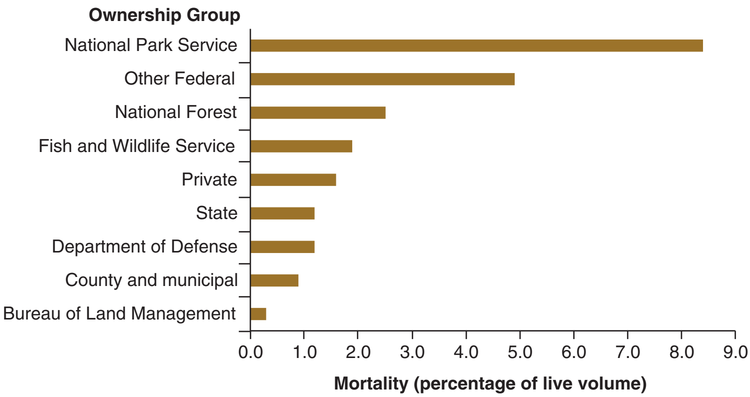


Figure 38.—Average annual live-tree mortality on forest land as a percentage of live volume by ownership, Northern Great Plains States, 2015.

What this means

Although mortality is a natural process as forest stands grow and change over time, high rates of mortality can indicate serious forest health issues or the decline of overmature forest stands because of aging. Ponderosa pine continues to suffer high mortality rates brought on by mountain pine beetle (Fig. 39) and subsequent wildfires. Eastern cottonwood continues to have high levels of mortality related to weather. American elm mortality is due in large part to Dutch elm disease (caused by the fungus *Ophiostoma ulmi*). These increased levels of mortality could affect the composition and structure of Northern Great Plains States forests in the future.

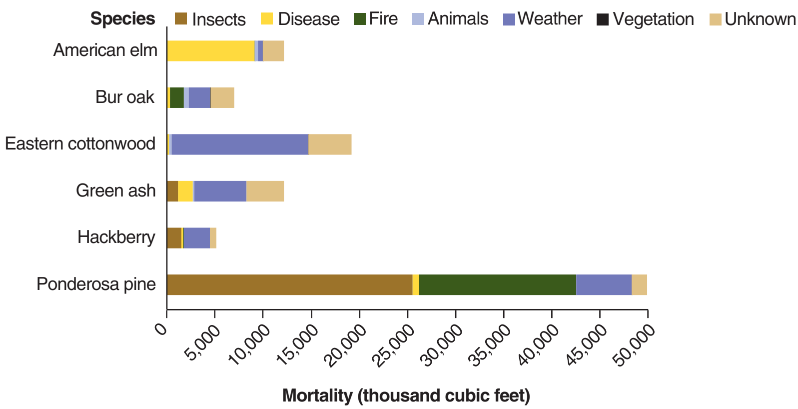


Figure 39.—Average annual mortality on forest land by primary cause for the six species with the highest live volume, Northern Great Plains States, 2015.

Removals

Background

Trees are removed from forest land to meet various management objectives or during land-use changes. Quantifying change due to removals aids in identifying trends in land-use change and forest management. However, because removals are generally recorded on a limited number of plots, the estimates for removals show greater variance than those for other attributes, such as growth, mortality, current volume, or area. Like forest growth, the rate at which trees are removed represents the average annual removals that occurred between 2010 and 2015.

There are three types of removals: harvest, mortality (trees killed during the harvesting process and left on the land), and diversion removals (living trees on land classified as forest land that are now on land classified as "nonforest" land). Diversion removals are trees removed from the forest land base due to a change in land use.

What we found

The average annual removals of live trees (at least 5 inches d.b.h.) on Northern Great Plains States forest land in the 2015 inventory was 79 million cubic feet or nearly 1 percent of the total live-tree volume in 2015. This is higher than the 69 million cubic feet reported as average annual removals in the 2010 inventory. Removals of softwood trees increased by nearly 12 million cubic feet between 2010 and 2015; removals of hardwoods decreased slightly from 2010 to 2015 (Fig. 40). Among individual species, Siberian elm had the highest rate of removals; an average of 4.2 percent of the total live volume of Siberian elm across the Northern Great Plains States was removed per year between 2010 and 2015 (Fig. 41). The removals rate was the lowest for quaking aspen at 0.1 percent of its total volume per year.

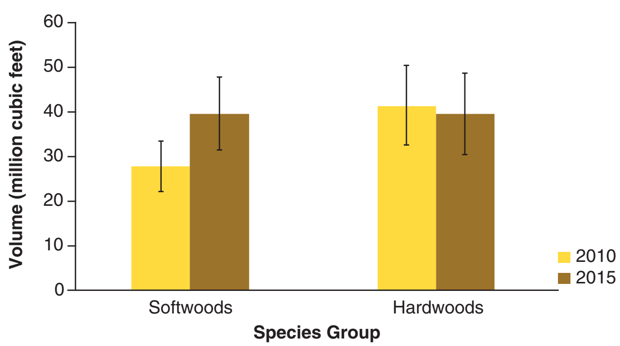


Figure 40.—Average annual removals of live trees on forest land, by major species group and inventory year, Northern Great Plains States. Error bars show a 68 percent confidence interval around the mean.

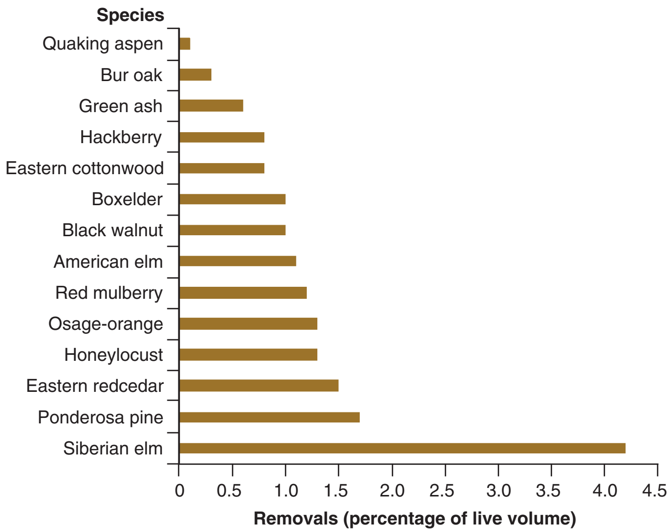


Figure 41.—Average annual removals of live trees on forest land as a percentage of volume for the 17 most voluminous species in the Northern Great Plains States, 2015.

The removals rate as a percentage of volume varies by ownership group. The rate is highest for National Forests (2.1 percent), followed by private landowners (0.7 percent), other Federal ownership (0.3 percent), and finally State and local government (0.2 percent).

An estimated 88 percent of the removals of live trees from Northern Great Plains States forest lands were due to harvesting. The remaining 12 percent of removals were the result of land-use change, where trees were not harvested but the land they grew on was reclassified by FIA from forest to nonforest land status.

What this means

Overall, the removals rate for the region increased between the 2010 and 2015 inventories. Removals rates are indicative of both land-use change and harvest in the Northern Great Plains States forests. Landowner objectives can have a large impact on removals rates. On average, National Forest lands in the Northern Great Plains are more actively managed than other ownerships. Due to variability based on different landowner and management objectives, removals rates should be monitored and evaluated on a case-by-case basis, especially at smaller scales (e.g., county) or for a specific species.

Forest Health Indicators

Hardwoods in eastern Nebraska. Photo by Dacia Meneguzzo, USDA Forest Service.

Tree Crown Health and Damage

Background

The condition of trees is influenced by various abiotic and biotic stressors, and it can be assessed by measuring crown health and observing the presence of damage. Abiotic stressors include drought, flooding, cold temperatures or freeze injury, nutrient deficiencies, soil physical properties affecting soil moisture and aeration, toxic pollutants, or mechanical or other human-caused injury. Biotic stressors include native or introduced insects, diseases, invasive plant species, and animals. Invasions by exotic diseases and insects are one of the gravest threats to the productivity and stability of forest ecosystems around the world (Liebhold et al. 1995, Pimentel et al. 2000, Vitousek et al. 1996).

Tree-level crown dieback is collected on a subset of forest inventory plots. Crown dieback is defined as recent mortality of branches with fine twigs and reflects the severity of recent stresses on a tree. A crown was labeled as "poor" if crown dieback was greater than 20 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 crown variable to use for predicting tree survival (Morin et al. 2015).

Tree damage is assessed for all trees at least 5 inches d.b.h. Up to three of the following types of damage can be recorded: insect damage, cankers, decay, fire, animal damage, weather, and logging damage. If more than two types of damage are observed, decisions about which two are recorded are based on the relative abundance of the damaging agents (USDA Forest Service 2017).

What we found

The incidence of poor crown condition for all species combined is relatively low across the Northern Great Plains States, but the highest occurrence of plots with greater than 20 percent of live-tree basal area with poor crown health is in Kansas (Fig. 42). Several species have proportions of live-tree basal area containing poor crowns above 10 percent, including Rocky Mountain juniper, green ash, and eastern redcedar. The species with the highest increase in the percentage of basal area in trees with unhealthy crowns between 2010 and 2015 is Rocky Mountain juniper, and the species with the largest decrease is eastern cottonwood. The proportion was stable for green ash (Table 4). Mean dieback ranged from 2 percent for ponderosa pine to 15 percent for Rocky Mountain juniper (Table 5).

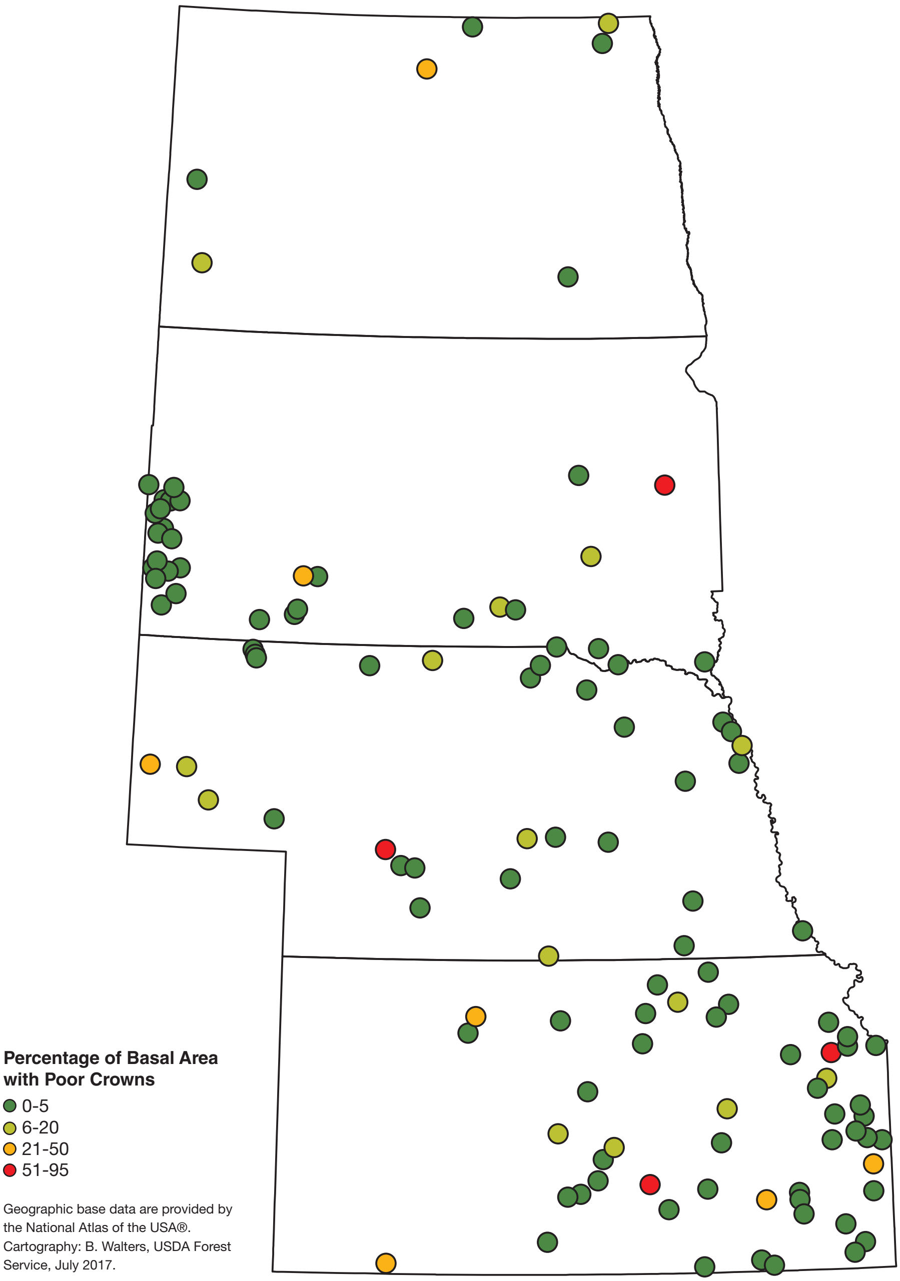


Figure 42.—Percentage of live-tree basal area with poor crowns, Northern Great Plains States, 2015.

Table 4.—Percentage of live-tree basal area with poor crowns, Northern Great Plains States, 2010 and 2015

Species	Percentage of basal area with poor crowns	
	2010	2015
Rocky Mountain juniper	0	20
Green ash	17	17
Eastern redcedar	0	10
Hackberry	0	6
Eastern cottonwood	14	6
Red mulberry	8	5
American elm	3	4
Osage-orange	5	3
Ponderosa pine	3	2
Bur oak	2	1

Table 5.—Mean crown dieback and other statistics for live trees (at least 5 inches d.b.h.) on forest land by species, Northern Great Plains States, 2015

Species	Trees	Mean	SE	Minimum	Median	Maximum
	number	---------------------------- *percent* ----------------------------				
Rocky Mountain juniper	44	15	3.4	0	5	70
Green ash	84	11	2.3	0	5	99
Red mulberry	50	10	2.4	0	5	99
Eastern cottonwood	42	8	1.3	0	5	40
Hackberry	72	8	1.5	0	5	99
American elm	117	6	1.4	0	5	99
Osage-orange	93	6	1.0	0	5	99
Eastern redcedar	184	5	0.8	0	0	60
Bur oak	195	4	0.5	0	0	50
Ponderosa pine	381	2	0.4	0	0	70

Damage was recorded on about 35 percent of inventoried trees in the Northern Great Plains States, but there is considerable variation in occurrence and type of damage between species. The most frequent damage on all species was decay (17 percent of trees), but it ranged from 2 percent or less of sampled eastern redcedar and ponderosa pine to more than 20 percent of the following sampled hardwood species: eastern cottonwood, green ash, Osage-orange, and red mulberry. Decay was also recorded on 10 percent or more of sampled American elm, bur oak, hackberry, and Rocky Mountain juniper trees. The only other damage type to occur on 10 percent or more of trees of any species was animal damage on ponderosa pine. The occurrence of all other injury types was very low (Fig. 43).

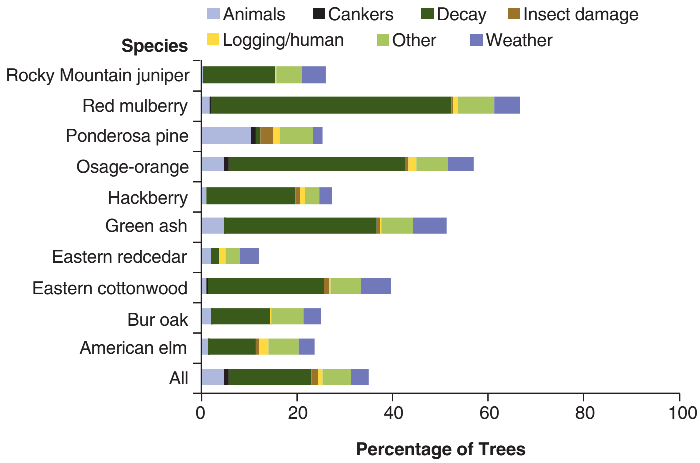


Figure 43.—Percentage of trees with damage, Northern Great Plains States, 2015.

What this means

The incidence of poor crown health is relatively common for several species in the forests of the Northern Great Plains States, including Rocky Mountain juniper, green ash, and eastern redcedar, but the sample size was too small to make a meaningful map of the spatial patterns of individual species. As in most Midwestern forests, decay is the most commonly observed damage in the Northern Great Plains States forests. This result is expected given that most of the forest land is in large diameter stands made up of mature trees. Surprisingly, red mulberry and Osage-orange have the highest relative occurrence of observed decay despite being classified as highly resistant to rot (Forest Products Laboratory 1999).

Forest Insects

Mountain Pine Beetle in the Black Hills

Background

The ponderosa pine-dominated forests of the Black Hills, a small mountain range on South Dakota's western border with Wyoming, have been experiencing high mortality caused by an outbreak of mountain pine beetle (*Dendroctonus ponderosae*; MPB) since the mid-1990s. MPB is a bark beetle native to western North America, with a range from northern Mexico to British Columbia, Canada. All species of pines within the MPB range are susceptible to attack, but the primary host in the Northern Great Plains is ponderosa pine. Tree death results from girdling due to gallery construction by the beetle and blockage of water-conducting cells by the growth of blue stain fungi, spores of which are carried by MPB (Gibson et al. 2009). During times of low population levels, MPB infests stressed trees, causing scattered mortality at low levels. Widespread tree mortality can occur when populations reach outbreak levels. Multiyear droughts, a series of mild winters, or dense stands may promote prolonged outbreaks.

What we found

With about 19 percent of total species composition, ponderosa pine is the most numerous tree species on Northern Great Plains States forest lands. About 82 percent of its more than 400 million trees occur in the Black Hills of South Dakota. Average annual mortality of ponderosa pine in the Black Hills has increased by 84 percent over the 2010 estimate, with insect-caused damage being the largest driver of that increase (Fig. 44). Although the exact species of insect causing death is not recorded by FIA measurements, it is safe to assume that insect mortality is largely caused by MPB. Region 2 of the Forest Service annually conducts an aerial detection survey of tree damage caused by insects and disease. In the Black Hills, maps of MPB damage and mortality are made based on interpretations of high-resolution aerial photographs and are supplemented by ground surveys conducted by entomologists (Harris et al. 2016). The 2015 study found that the Black Hills MPB epidemic may be slowing, with fewer new acres of trees being affected than in recent years. Areas of damage or mortality in the Black Hills are located mostly in the central and northern portion and affect all ownerships of forest land (Fig. 45).

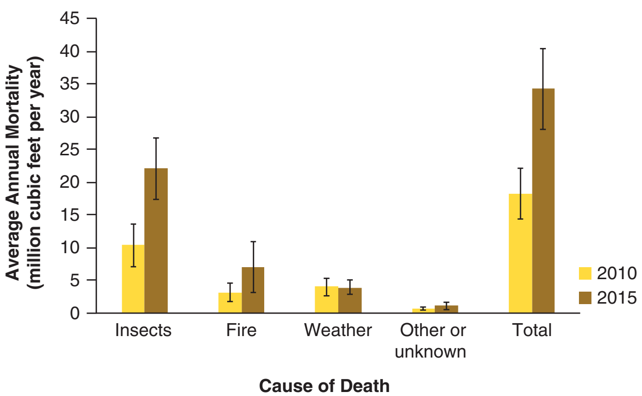


Figure 44.—Average annual mortality of ponderosa pine trees (at least 5 inches d.b.h.) by cause of death, Black Hills, South Dakota. Error bars show a 68 percent confidence interval around the mean.

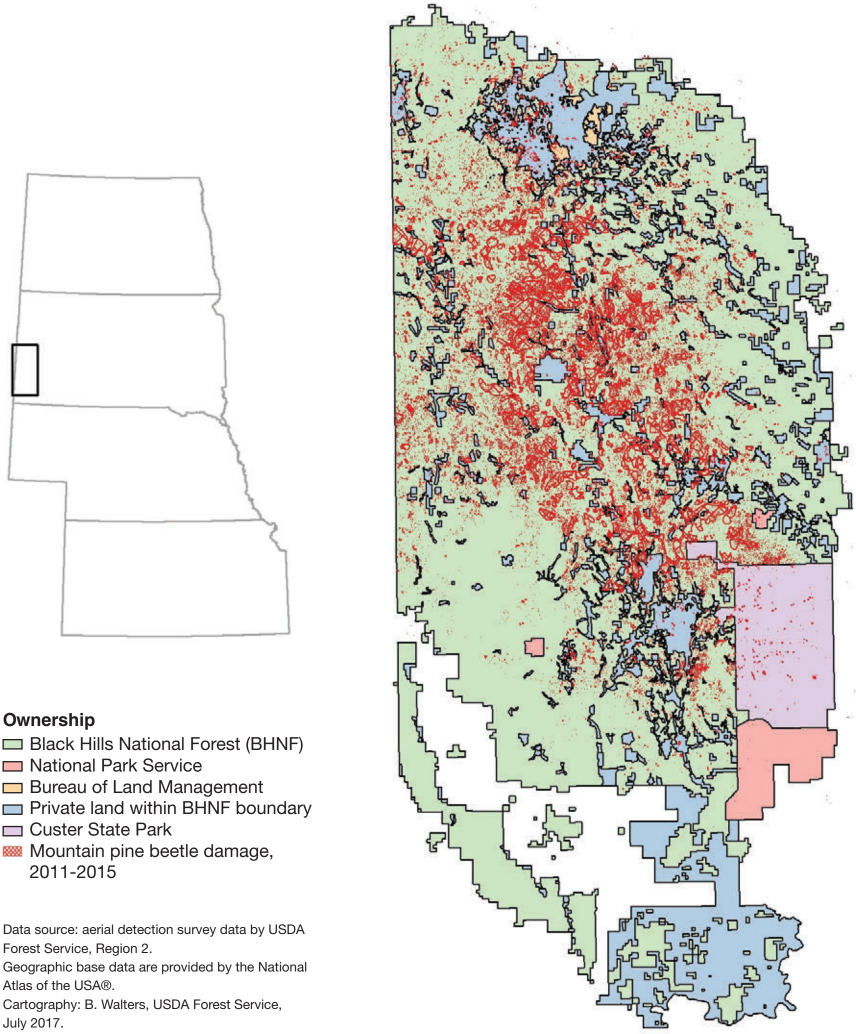


Figure 45.—Areas identified with mountain pine beetle mortality in the Black Hills, by ownership, 2011-2015. Inset shows location in South Dakota.

What this means

MPB has had a large impact on the ponderosa pine resource in the Black Hills over the last two decades. Managers and others hope that the recent trend of decreasing rate of new acres affected will be sustained. In the meantime, mitigation efforts by the State of South Dakota, the Black Hills National Forest, and private landowners are still underway to reduce the outbreak of MPB. Management practices such as thinning and removal of infested trees have had some success. For further reading on MPB and a history of control attempts, see Graham et al. (2016).

Emerald Ash Borer

Background

Native to Asia, emerald ash borer (*Agrilus planipennis*; EAB) is a wood-boring beetle that attacks and kills all major North American species of ash. Although EAB shows some preference for stressed trees, all trees at least 1 inch in diameter are susceptible (Herms and McCullough 2014). EAB was first detected in North America near Detroit, Michigan in 2002. Since then, EAB has been found in most states in the eastern United States, as well as in the Canadian provinces of Ontario and Quebec. EAB was detected in eastern Kansas in 2012 and, though not identified during the 2015 inventory, EAB was found in eastern Nebraska in 2016.

What we found

Forest land in the Northern Great Plains States contains an estimated 203.8 million ash trees (1 inch d.b.h. or larger), which represent 9 percent of total species composition and occur in varying densities throughout the region (Fig. 46). Ash is most abundant in North Dakota, where it makes up 25 percent of the tree resource. Ash species account for 8.5 billion cubic feet of live-tree volume in the region. Ash mortality in Kansas, North Dakota, and South Dakota has remained stable since 2010, whereas ash mortality in Nebraska has doubled (Fig. 47). Nebraska had the highest mortality rate, with an estimated yearly loss of about 3.3 percent of ash volume in 2015. Ash mortality occurred throughout the Northern Great Plains region (Fig. 48).

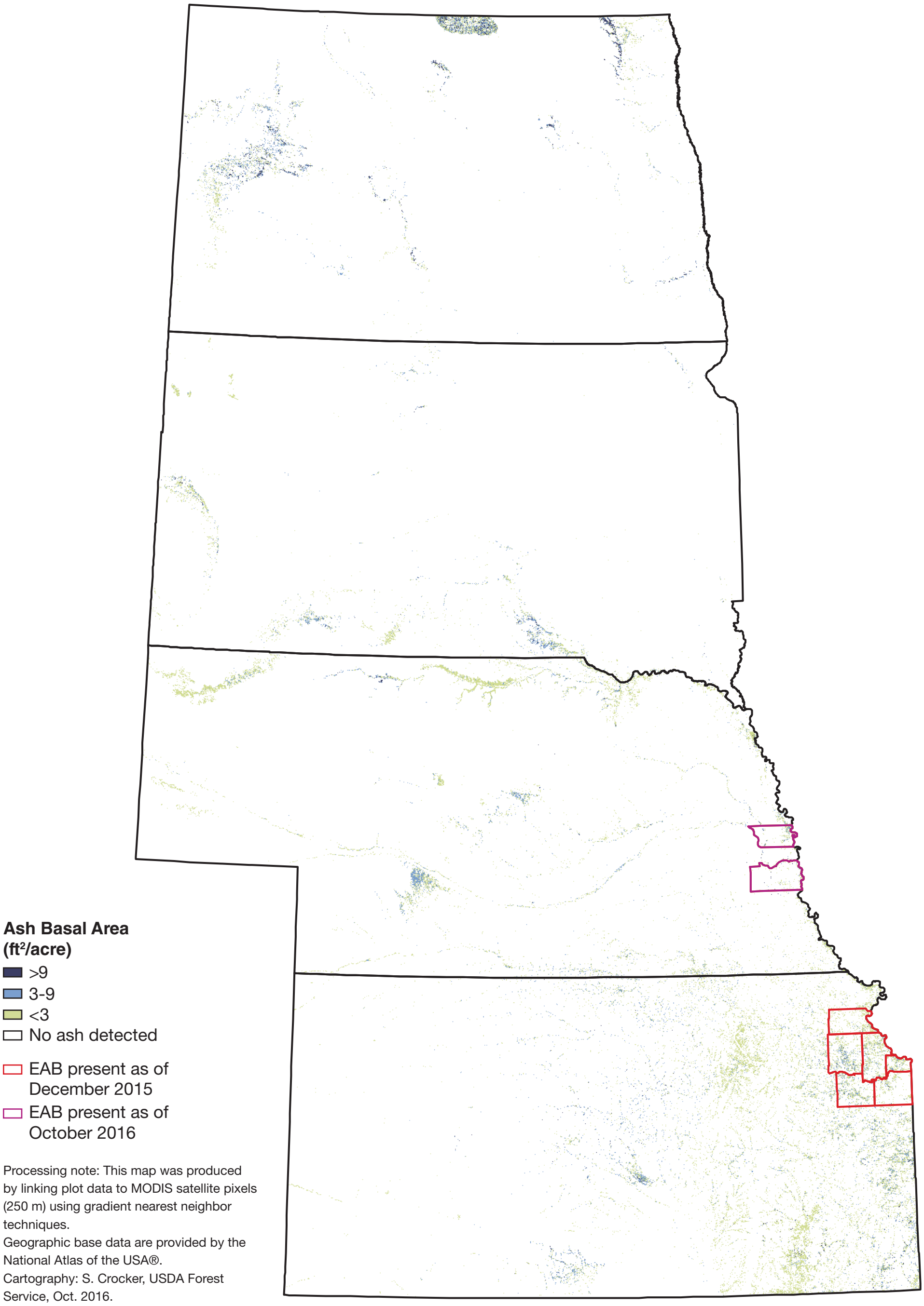


Figure 46.—Distribution of ash on forest land, Northern Great Plains States, 2009.

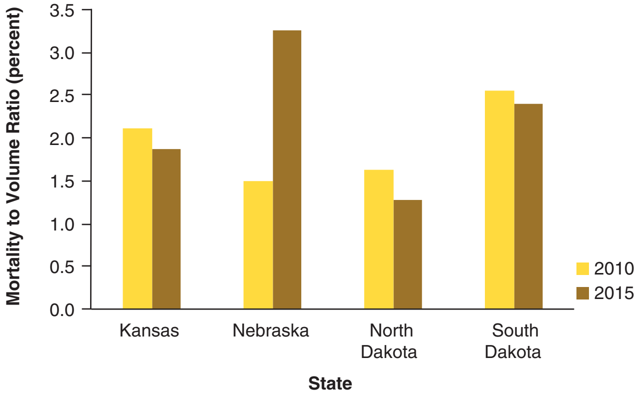


Figure 47.—Average annual mortality of ash trees (at least 5 inches d.b.h.) as a percentage of ash volume on forest land, Northern Great Plains States.

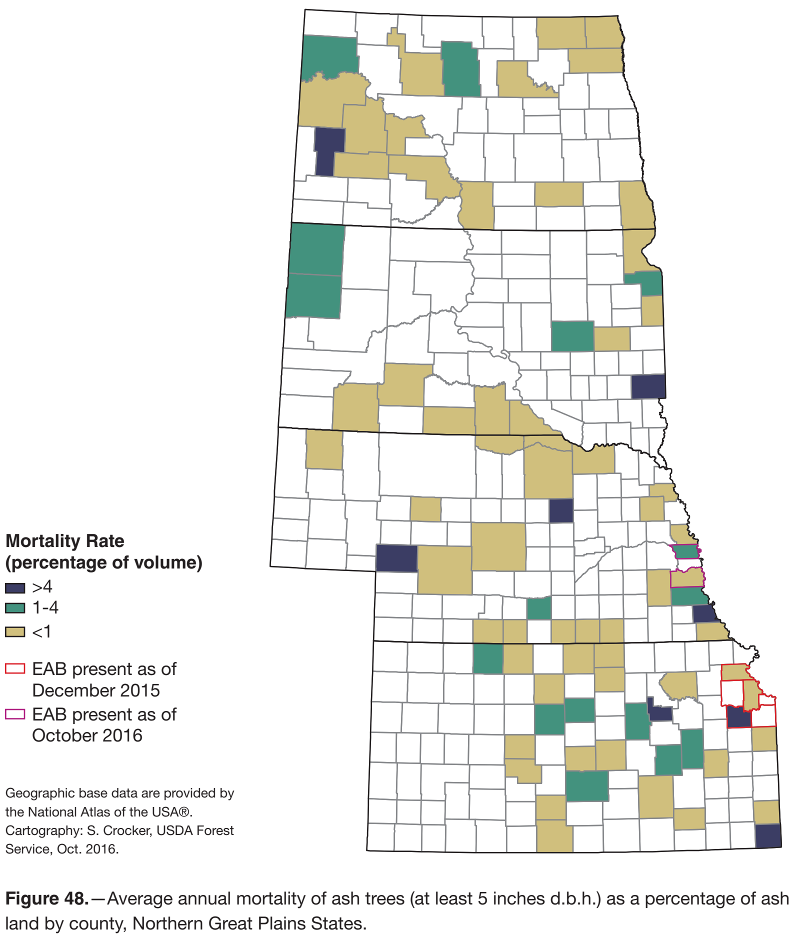


Figure 48.—Average annual mortality of ash trees (at least 5 inches d.b.h.) as a percentage of ash volume on forest land by county, Northern Great Plains States.

What this means

EAB has caused extensive ash mortality throughout the eastern United States and it represents a significant threat to all ash trees in the Northern Great Plains. Ash mortality is high in many counties throughout the region, but EAB has been identified in only a few counties. Counties without a confirmed infestation but with high ash mortality serve as good candidates for increased EAB survey efforts. Ash mortality is expected to increase as EAB spreads. The loss of ash in forested settings will affect species composition and alter community dynamics. Additionally, mortality of ash in windbreaks and riparian areas will have implications for erosion control and water quality. Continued monitoring of ash resources will help to identify the long-term impacts of EAB throughout the Northern Great Plains.

Thousand Cankers Disease

Background

Thousand cankers disease (TCD) is a disease complex that primarily affects black walnut and results from the interaction between the *Geosmithia morbida* fungus and the walnut twig beetle, *Pityophthorus juglandis* (Seybold et al. 2013). TCD occurs throughout the western United States and has been introduced to several eastern states. Though TCD has not been detected in the four-State region, the disease has been confirmed in neighboring Colorado.

What we found

Black walnut has a limited distribution in the Northern Great Plains States, where it occurs in the eastern half of South Dakota, Nebraska, and Kansas. It is not found in North Dakota. The heaviest concentrations of black walnut are in eastern Kansas (Fig. 49). Across the region, there are an estimated 26.5 million black walnut trees (at least 1.0 inch d.b.h.) on forest land. Live black walnut trees (at least 5.0 inches d.b.h.) account for nearly 233.0 million cubic feet of volume. Mortality of black walnut as a percentage of total growing-stock volume has increased in Kansas and Nebraska between 2010 and 2015; no walnut mortality was recorded in South Dakota during either inventory (Fig. 50).

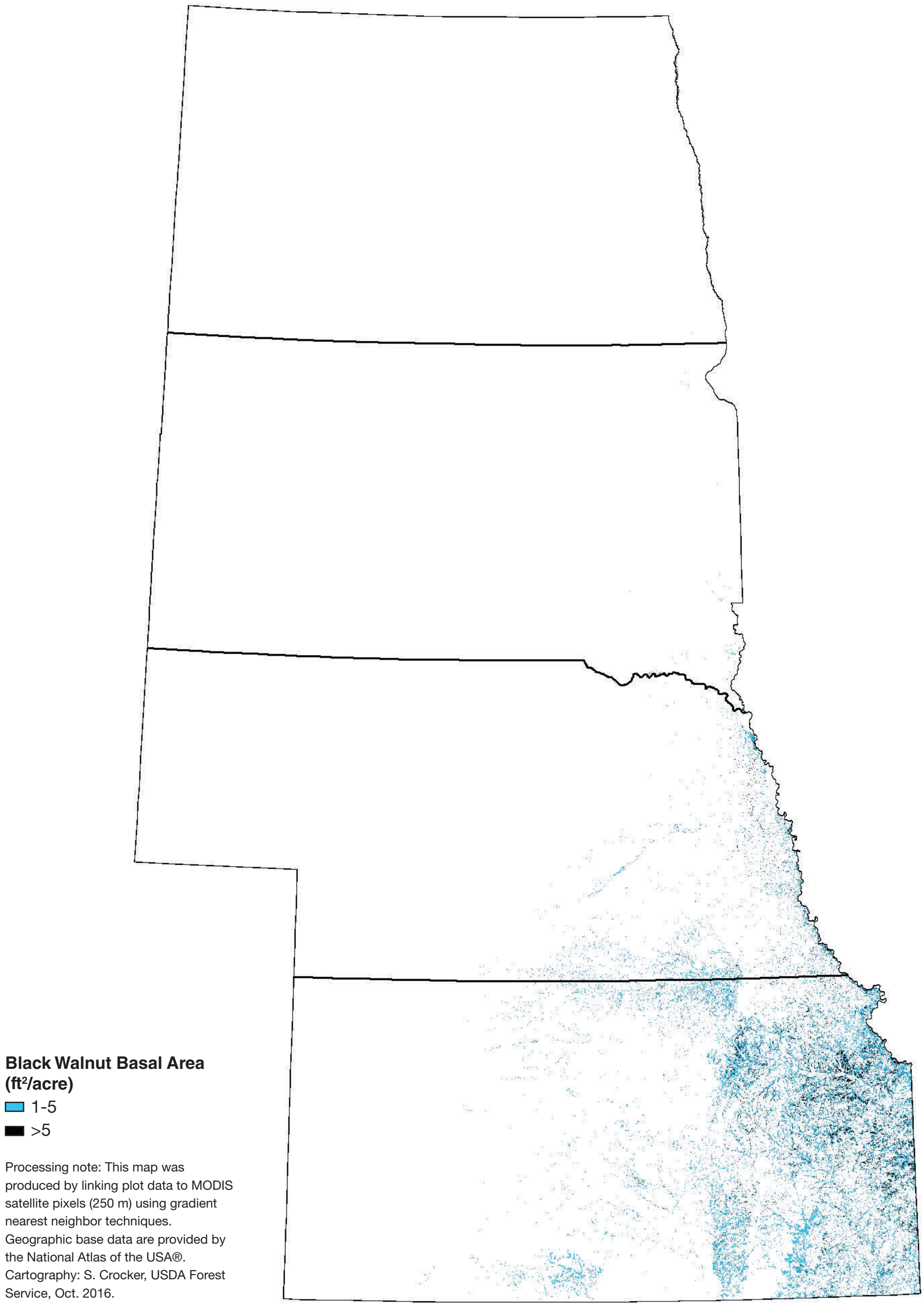


Figure 49.—Basal area of black walnut on forest land, Northern Great Plains States, 2009.

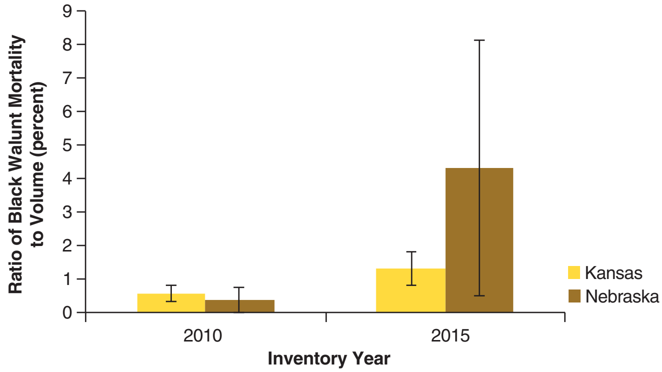


Figure 50.—Average annual mortality of black walnut trees as a percentage of total growing-stock volume on forest land by inventory year, Kansas, and Nebraska. Error bars show a 68 percent confidence interval around the mean.

What this means

Black walnut is an ecologically and economically important component of the woodland and community landscapes of Kansas, Nebraska, and South Dakota. The introduction of TCD has the potential to cause extensive walnut mortality and dramatically affect the region's forest ecosystem and commercial timber products industry.

Invasive Plants

Background

Invasive plant species (IPS) are defined in this report as both native and nonnative species that can cause negative ecological effects. These species can quickly invade forests, thereby changing water, light, and nutrient availability (Kuebbing et al. 2014). IPS can form dense monocultures that reduce tree regeneration and degrade wildlife habitat quality by altering forest structure and forage availability (Pimentel et al. 2005). IPS can also have negative ecological and economic impacts on agricultural systems (Kurtz 2013). An example is common barberry (*Berberis vulgaris*), an alternate host for wheat stem rust (*Puccinia graminis*), which can cause the complete loss of grain fields. Common buckthorn is another troublesome IPS as it is an alternate host for the soybean aphid (*Aphis glycines*). Although these invaders have some beneficial uses such as culinary and medicinal purposes, and soil contaminant extraction (Kurtz 2013), the negative effects are cause for concern, especially in the Northern Great Plains States, where agriculture is the dominant land use. Billions of dollars are spent each year for inspection, management, and mitigation of IPS (Kurtz 2013, Pimentel et al. 2005).

To aid in monitoring these species, FIA assessed the presence of 40 IPS (39 species and one undifferentiated genus; hereafter referred to as "invasives") on 245 forested plots (a subset of FIA plots called Phase 2, or P2, invasive plots) (USDA Forest Service 2010) in the Northern Great Plains States for the 2015 inventory. To maintain regional consistency, the species list is not customized for these four States but represents native and nonnative species of regional concern. When reviewing these data, one must remember that the inventory takes place only on forested land so land with less forested area will have fewer plots.

What we found

Of the 40 invasives monitored (Appendix 2), 13 are present in the Northern Great Plains States (Table 6). Nonnative bush honeysuckles and Siberian elm are the most commonly observed species (19 plots; 7.8 percent each). Nonnative bush honeysuckles are more common on plots on the eastern half of the four States (Fig. 51), whereas Siberian elm was found throughout the region (Fig. 52). Multiflora rose is the second most common invasive and occurs on 7.3 percent of the plots.

Table 6.—Invasive plant species recorded on Forest Inventory and Analysis P2 invasive plots, Northern Great Plains States, 2015

Species	Number of Occurrences	Percentage of Plots
Nonnative bush honeysuckles	19	7.8
Siberian elm	19	7.8
Multiflora rose	18	7.3
Garlic mustard	17	6.9
Bull thistle	15	6.1
Reed canarygrass	13	5.3
Canada thistle	11	4.5
Leafy spurge	9	3.7
Russian olive	4	1.6
Autumn olive	3	1.2
Common buckthorn	3	1.2
Japanese honeysuckle	3	1.2
Black locust	1	0.4

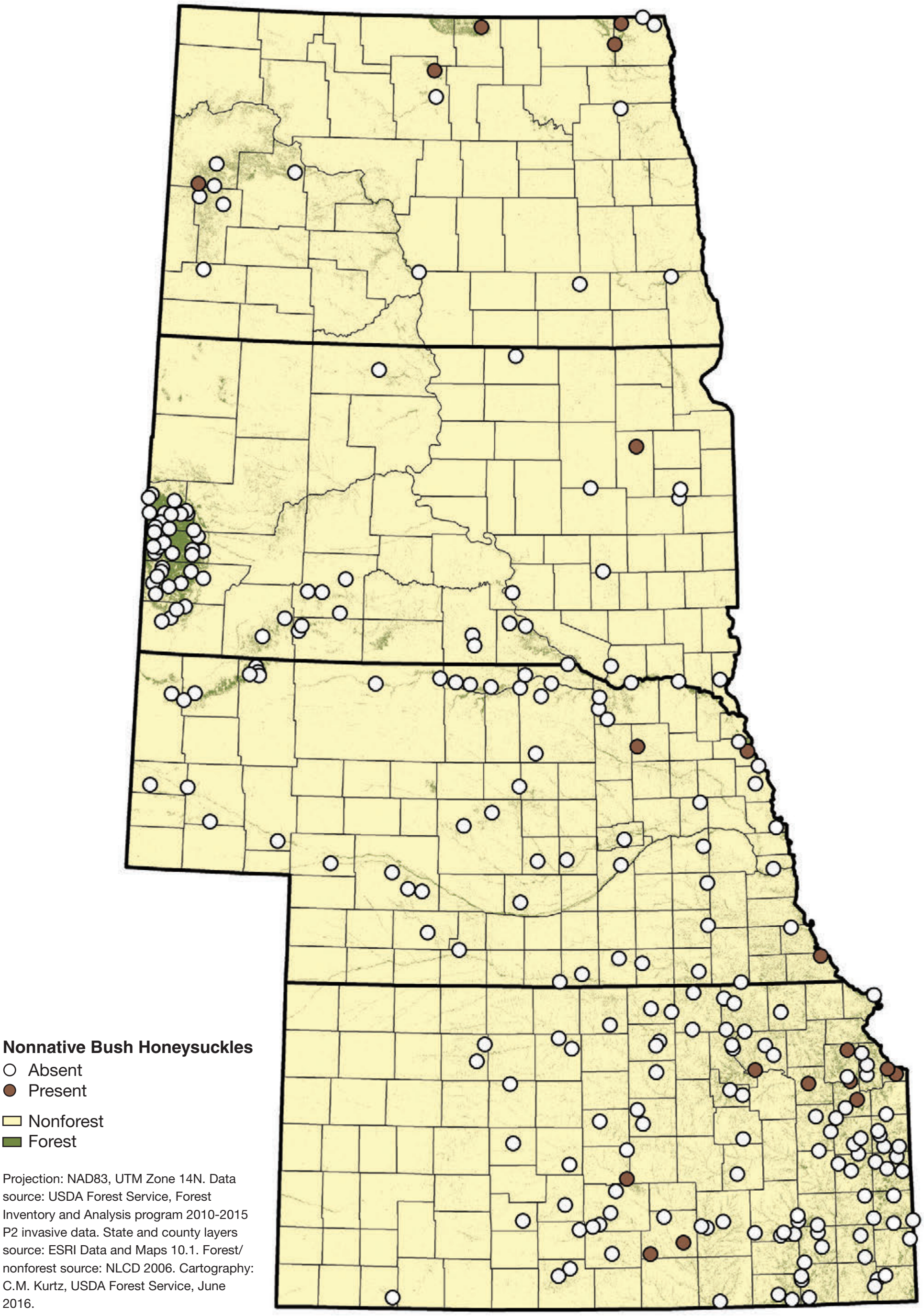
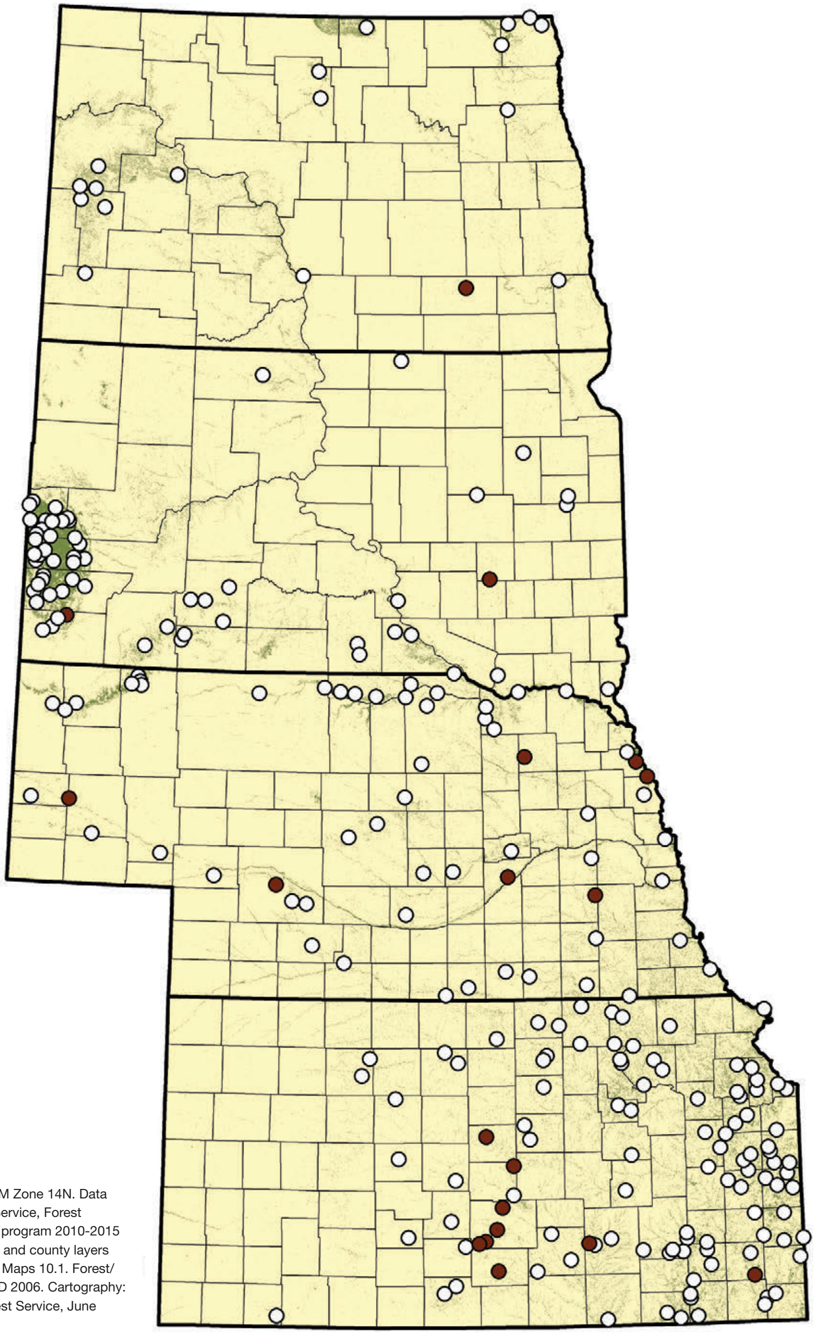


Figure 51.—Presence of nonnative bush honeysuckles on Forest Inventory and Analysis P2 invasive plots, Northern Great Plains States, 2015. Plot locations are approximate.



Projection: NAD83, UTM Zone 14N. Data source: USDA Forest Service, Forest Inventory and Analysis program 2010-2015 P2 invasive data. State and county layers source: ESRI Data and Maps 10.1. Forest/nonforest source: NLCD 2006. Cartography: C.M. Kurtz, USDA Forest Service, June 2016.

Figure 52.—Presence of Siberian elm on Forest Inventory and Analysis P2 invasive plots, Northern Great Plains States, 2015. Plot locations are approximate.

The number of invasives found varied by state. Kansas and Nebraska each have 10 of the monitored species present on P2 invasive plots. Seven of the invasives are present in South Dakota and six are present in North Dakota. The most common species also varied by state (Table 7).

Table 7.—The three most commonly observed invasive plant species by Northern Great Plains State, 2015

State and Three Most Common Invasive Plant Species	Number of Occurrences	Percentage of Plots
Kansas		
Multiflora rose	15	13.9
Garlic mustard	15	13.9
Nonnative bush honeysuckles	10	9.3
Nebraska		
Reed canarygrass	7	11.7
Siberian elm	7	11.7
Leafy spurge	6	10
North Dakota		
Nonnative bush honeysuckles	5	27.8
Reed canarygrass	4	22.2
Leafy spurge	3	16.7
South Dakota		
Bull thistle	8	13.6
Canada thistle	6	10.2
Siberian elm	2	3.4

Some changes were observed since the 2010 inventory. Three species that were recorded in the 2010 inventory (saltcedar, dames rocket, and Oriental bittersweet) were not documented on the 2015 P2 invasive plots. The two most common invasives in North Dakota in 2015 were different from the two most commonly found in the 2010 inventory. But for the three other States, the two most common IPS remained the same (Haugen et al. 2013, Meneguzzo et al. 2012, Moser et al. 2013, Piva et al. 2013). However, it is also important to note that for this report the species of nonnative bush honeysuckles were combined into one group instead of reporting each one at the species level.

What this means

Invasive species are a concern throughout the Northern Great Plains because many IPS are able to outcompete native species, thereby changing the species composition of forested ecosystems. Furthermore, IPS can cause other negative impacts by reducing timber yield and aesthetic beauty. Several characteristics contribute to their success as competitors, such as prolific seed production, rapid growth, vegetative propagation, and endurance of harsh conditions. Many factors contribute to forest invasion such as ungulates, development, fragmentation, and timber harvesting; however, some IPS can establish with little to no disturbance. Additional investigation may increase our understanding of how site, regional characteristics, and forest dynamics influence IPS presence and success. Even with limited samples, continual monitoring and reporting of IPS informs managers and the public of their occurrence and spread.

Standing Dead Trees

Background

Specific habitat features such as nesting cavities and standing dead trees (at least 5 inches d.b.h.) 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). Lewis's woodpecker (*Melanerpes lewis*)—named after Meriwether Lewis of the Lewis and Clark expedition—prefers habitats containing many snags, as found along the edges of the pine forests and streamside cottonwood groves of western Nebraska and South Dakota. 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 material, which provides other habitat features for wildlife. The number and density of standing dead trees, together with decay classes, species, and size, define an important wildlife habitat feature across Northern Great Plains States forests. Stage of decay is described by one of five classes as follows: 1) All limbs and branches are present; the top of the crown is still present; all bark remains; sapwood is intact, with minimal decay; heartwood is sound and hard. 2) There are few limbs and no fine branches; the top may be broken; a variable amount of bark remains; sapwood is sloughing with advanced decay; heartwood is sound at base but beginning to decay in the outer part of the upper bole. 3) Only limb stubs exist; the top is broken; a variable amount of bark remains; sapwood is sloughing; heartwood has advanced decay in upper bole and is beginning at the base. 4) Few or no limb stubs remain; the top is broken; a variable amount of bark remains; sapwood is sloughing; heartwood has advanced decay at the base and is sloughing in the upper bole. 5) No evidence of branches remains; the top is broken; less than 20 percent of the bark remains; sapwood is gone; heartwood is sloughing throughout (USDA Forest Service 2017).

What we found

Between 2010 and 2015, FIA collected data on standing dead trees of numerous species and sizes in varying stages of decay. According to the inventory data, most (more than 78 percent) of the estimated 93.9 million standing dead trees were present in the oak/hickory, ponderosa pine, elm/ash/cottonwood, and aspen/birch forest-type groups. Among the most common standing dead tree species were ponderosa pine, American elm, green ash, bur oak, and quaking aspen (Fig. 53). Ponderosa pine made up 36 percent of all standing dead trees across the Northern Great Plains States. The smallest diameter class had the most standing dead trees, and the number of standing dead trees generally decreases as diameter increases (Fig. 54). That is, the numbers of smaller diameter standing dead trees substantially exceeded those of larger diameter trees. Compared to larger dead trees, standing dead trees of smaller diameter tended to have less advanced decay; a decay class of 2 was most prevalent across standing dead trees in the 5.0- to 6.9-inch through 13.0- to 14.9-inch and 19.0+ inch diameter classes. The exceptions were the diameter classes 15.0-16.9 inches and 17.0-18.9 inches.

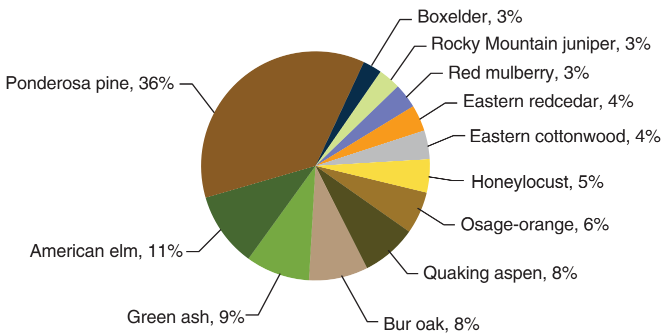


Figure 53.—Proportion of standing dead trees for the 12 most common standing dead trees species, Northern Great Plains States, 2015.

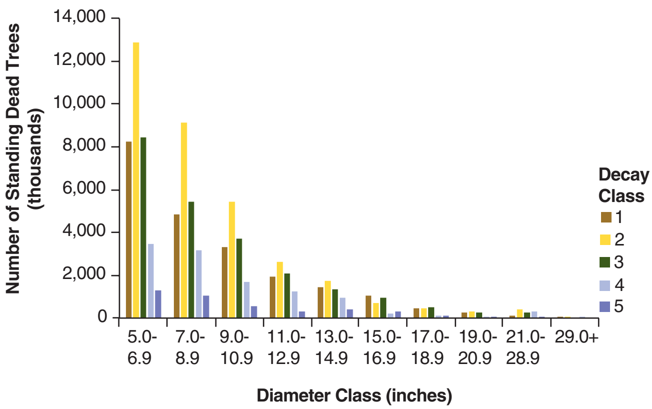


Figure 54.—Distribution of standing dead trees by decay and diameter classes for all standing dead trees, Northern Great Plains States, 2015.

What this means

Among possible reasons for standing dead trees across the Northern Great Plains States forests are diseases and insects, weather damage, fire, flooding, drought, and competition (Fig. 55). The dominance of ponderosa pine, American elm, green ash, bur oak, and aspen snags in particular might be accounted for by insects such as mountain pine beetle, ash bark beetle (*Hylesinus* species), and native ash borers, and diseases such as Dutch elm disease, bur oak blight (*Tubakia iowensis*), Hypoxylon canker, and *Phellinus tremulae* (of fungal origin). Additionally, normal forest maturation dynamics may be responsible for high mortality rates in the population of these species. Smaller trees and certain early-successional species suffer competition-induced deaths that ensure the creation of small openings in mature forests, perpetuating tree regeneration. Snags provide areas for foraging, nesting, roosting, hunting perches, and cavity excavation for wildlife ranging from primary colonizers such as insects, bacteria, and fungi to birds, mammals, and reptiles. Most cavity nesting birds are insectivores that help to control insect populations. 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 the Great Plains.

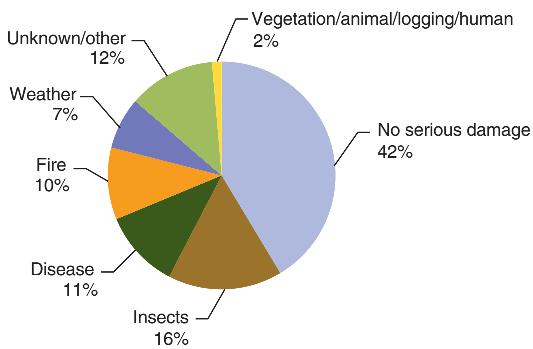


Figure 55.—Cause of tree mortality as a percentage of standing dead trees on forest land, Northern Great Plains States, 2015.

Cottonwood in the Northern Great Plains States

Background

Eastern cottonwood (*Populus deltoides*) is a very important tree species throughout the Northern Great Plains States. Cottonwood often occurs as a dominant or codominant component of floodplain and bottomland hardwood forests (Myers et al. 1984). It is a principal species in riverfront forests in the eastern United States (Meadows and Nowacki 1996). The maintenance of eastern cottonwood-dominated stands depends on periodic flooding (Wilson 1970). Most of these riparian areas tend to be in early successional stages and are composed chiefly of scrub willows (*Salix* spp.) interspersed with occasional cottonwood stands (Minckley and Brown 1982). In the Northern Great Plains States, cottonwoods are a major component of riparian forests and moist woodlands that provide critical habitat for many wildlife species (Bjugstad 1977, Hopkins 1984). These woodland areas may constitute up to 50 percent of the habitat for deer (*Odocoileus virginiana*) and 70 percent of the habitat for sharp-tailed grouse (*Tympanuchus phasianellus*). Domestic livestock use these areas for shade, forage, and water in the summer and for thermal cover in the winter (Bjugstad 1977). Historically, Native Americans of the Northern Great Plains and early pioneering settlers relied heavily on cottonwood for their survival (Warner and Chase 1956). These trees supplied building construction materials for their lodges and forts and provided fuel for heating and cooking.

Forest is classified as one of the cottonwood forest types if cottonwood trees make up a plurality of total stocking. An estimated 6 percent of the total area of forest land is found in the cottonwood forest types. Stand-size class distribution of the cottonwood forest types has changed over time in the Northern Great Plains to where currently, large diameter size stands represent 87 percent of the total cottonwood forest type acreage. Over time the total area of cottonwood held in private ownership has remained high with over 73 percent in private ownership in 2015.

What we found

Within the Northern Great Plains States, an estimated 361,000 acres are classified as the cottonwood forest type with an additional 77,000 acres in the cottonwood/willow forest type (Fig. 56). In addition to forest lands that are dominated by cottonwood (and thus classified as being in the cottonwood forest types), some cottonwood can also be found within other forest types throughout the Northern Great Plains States. Cottonwood plays a substantial role in some forest types, but in others it is a minor component. According to the 2015 inventory, cottonwood represented more than 12 percent of the total volume in the willow forest type, 6 percent of volume in the sugarberry/hackberry/elm/green ash forest type, and only 0.2 percent of the eastern redcedar forest type.

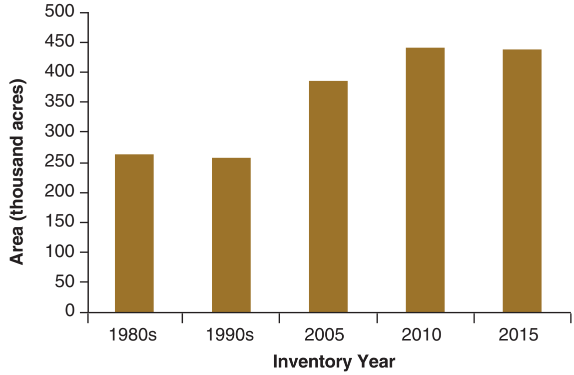


Figure 56.—Area of cottonwood forest types, Northern Great Plains States.

Stand-size class

The stand-size class distribution of the cottonwood forest types has changed over time in the Northern Great Plains States. Small diameter stands made up about one-fifth (19 percent) of all cottonwood forest area in the 1980s, dropping to only 3 percent by 2005. Between 2005 and 2015, the declining trend reversed and the area of small diameter stands increased (Fig. 57). Large diameter stands, however, increased substantially in area since the 1980s and currently make up 87 percent of all cottonwood forests, and medium diameter stands 8 percent. On a state-by-state basis, Kansas, Nebraska, and South Dakota followed the regional trend in the 1980s and 1990s with the majority of cottonwood forest types in the large diameter stands. Since 2005, all four Northern Great Plains States have followed similar trends toward large diameter stand sizes.

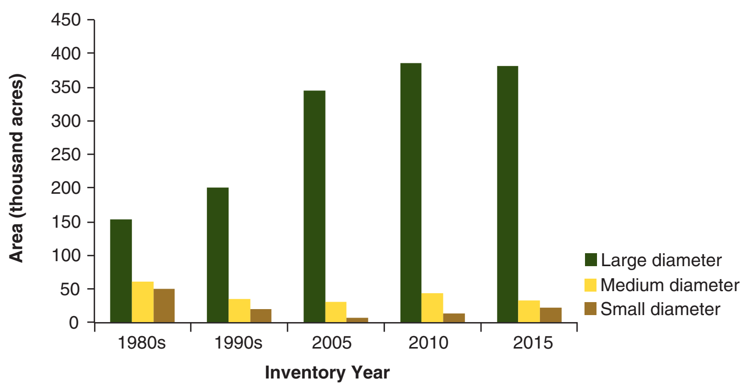


Figure 57.—Area of cottonwood forest types by stand-size class and inventory year, Northern Great Plains States.

Stocking

A stand is considered fully stocked when trees occupy the amount of space that creates optimum growth and tree form. The level of stocking has increased within the cottonwood forest types; fully stocked stands have nearly doubled since the 1980s, going from about 19 percent of cottonwood forest land to about 38 percent in 2015 (Fig. 58). Almost 39 percent of the cottonwood forest types are medium stocked stands, and only 9 percent of the cottonwood stands are considered poorly stocked or nonstocked, in contrast with 44 percent in the 1980s. Compared to all live stocking across all forest types within the Northern Great Plains States, percentages of the cottonwood forest types in fully and medium stocked classes are higher than for all forest types and have no estimated area classified as nonstocked (Fig. 59).

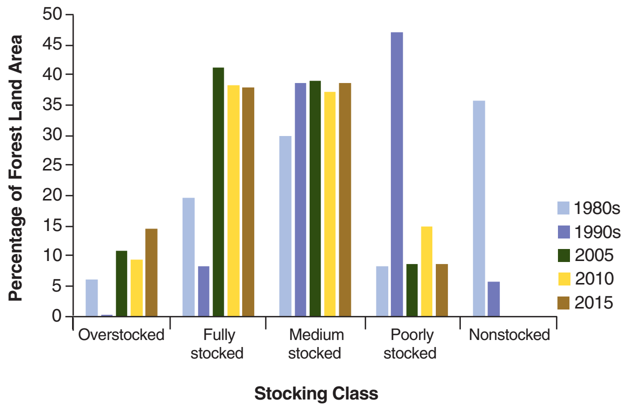


Figure 58.—Area of cottonwood forest types as a percentage of total forest land area by stocking class and inventory year, Northern Great Plains States.

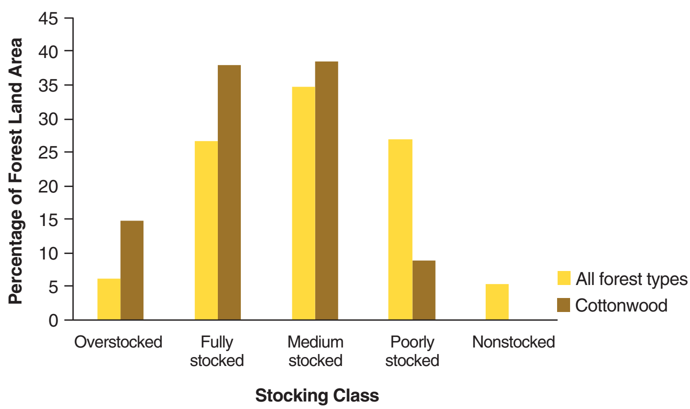


Figure 59.—Proportion of total forest land area for all forest types and cottonwood forest types by stocking class, Northern Great Plains States, 2015.

Ownership

According to the 2015 inventory, nearly three-fourths of the Northern Great Plains States forest land is privately owned. Cottonwood forest land in the region follows a similar pattern with 73 percent held in private ownership. Overall, the distribution of ownership of the cottonwood resource in the Northern Great Plains States has been relatively static since 2005 (Fig. 60). Compared to 1980s ownership patterns, the percentage of Federally owned cottonwood forests in 2015 has been reduced by half while the percentage of State and local government ownership has doubled.

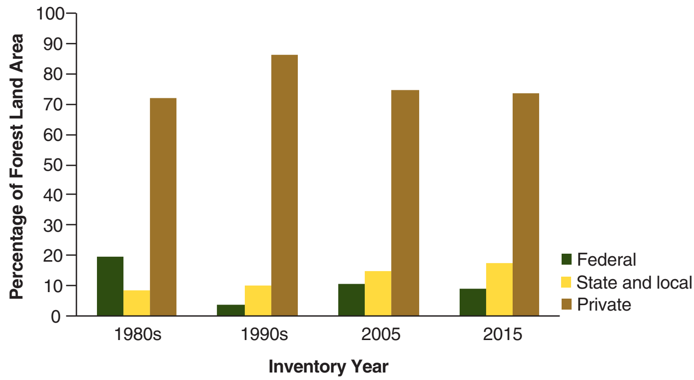


Figure 60.—Proportion of cottonwood forest land area by ownership and inventory year, Northern Great Plains States.

Number of trees

There are currently an estimated 28.3 million cottonwood trees across the forest lands of the Northern Great Plains States. Of these, 54 percent are sawtimber-size trees (11.0 inches d.b.h. or larger for hardwoods), 26 percent are poletimber-size trees (at least 5.0 inches d.b.h. and less than 11.0 inches d.b.h.), and 20 percent are sapling-size trees (at least 1.0 inch d.b.h. and less than 5.0 inches d.b.h.). In contrast with the larger size classes, sapling-size cottonwood trees declined in number between 2010 and 2015 (Fig. 61).

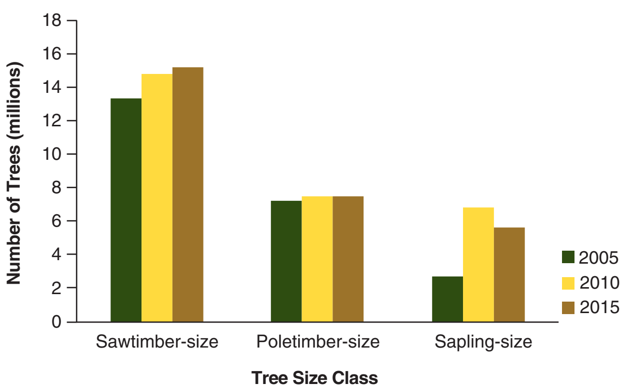


Figure 61.—Number of cottonwood trees on forest land by tree size class and inventory year, Northern Great Plains States.

If we compare the cottonwood percentages by tree size class to that of all trees found on forest lands across the Northern Great Plains States, we see opposite trends in the sawtimber- and sapling-size trees (Fig. 62). Only 11 percent of all trees are sawtimber size while the majority (64 percent) are in the sapling-size class.

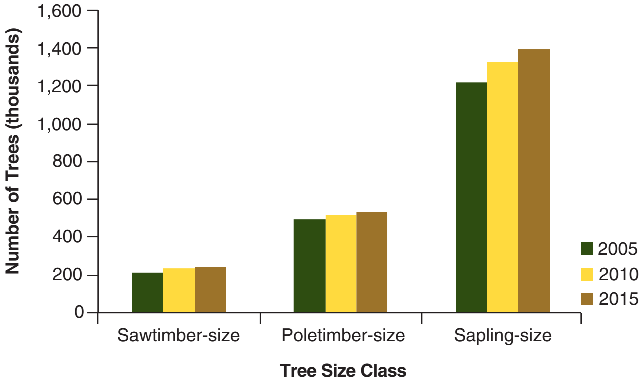


Figure 62.—Number of all live trees on forest land by tree size class and inventory year, Northern Great Plains States.

Physiographic class

Seventy-three percent of cottonwood forests are found in the floodplains and bottomlands of the Northern Great Plains (Fig. 63); this area represents nearly one-fourth (24 percent) of all floodplain/bottomland forest types. These cottonwood forests are dominated by large diameter stands (Fig. 64). Medium and small diameter stands make up only about 15 percent of all floodplain and bottomland cottonwood forests. There is no estimated area of small diameter cottonwood stands in the broad floodplains/bottomlands physiographic class, which may indicate a lack of young stands and regeneration.

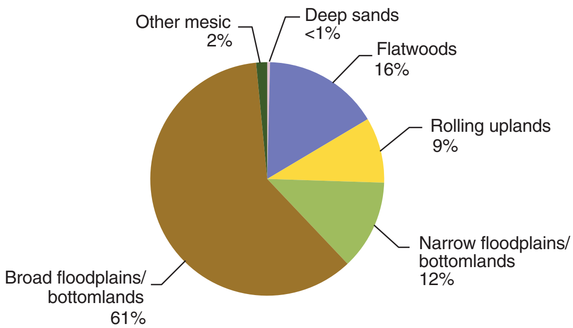


Figure 63.—Cottonwood forest types by physiographic class, Northern Great Plains States, 2015.

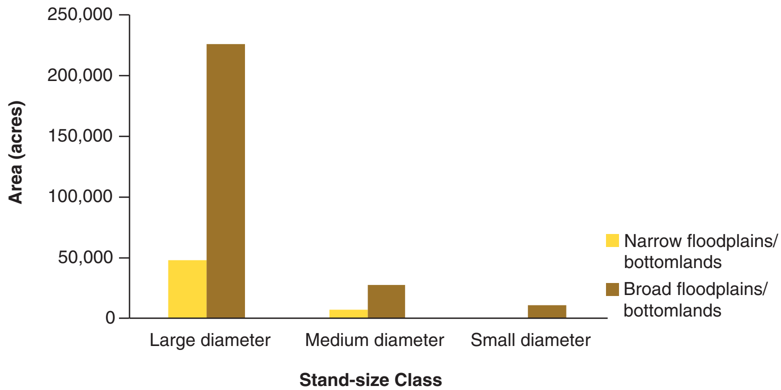


Figure 64.—Area of the cottonwood forest types by stand-size class and physiographic class, Northern Great Plains States, 2015.

Stand age

Stand age is estimated based on core samples from dominant and codominant trees within a stand and provides information on the successional status of forest lands. Therefore, stand age can give us another clue about the cottonwood resource across the Northern Great Plains States. Cottonwood is considered the fastest growing tree in the Great Plains (Read 1958). Cottonwoods are a pioneer species; they are short-lived, seldom surviving for more than 80 years (Natural Resources Conservation Service 2018). Considering an 80-year life span, we look at the age distribution of cottonwood forest types: 29 percent are in age classes up to 40 years old, more than half (59 percent) fall in the 41- to 71-year age classes, and the remaining 12 percent are in the 81-year and older age classes (Fig. 65).

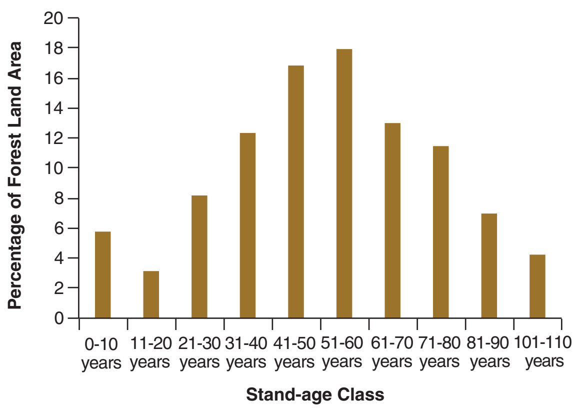


Figure 65.—Age distribution of cottonwood forest types on forest land, Northern Great Plains States, 2015.

What this means

The lack of young stands of cottonwood across the Northern Great Plains, along with the low rate of regeneration as expressed by the low number of sapling-size stands, hints at the shifts in natural disturbance regimes required to promote cottonwood forests. In this region, recruitment and survival of cottonwood have been impeded by the construction of dams and reservoirs. Changes in magnitude and frequency of floods, rates of sedimentation, and rates of meander migration contribute to the reduction of suitable sites (Bradley and Smith 1986, Johnson et. al. 1976). Without the disturbance that is required to create suitable seedbeds and promote root suckering, less cottonwood regeneration occurs and there are relatively fewer younger trees, which may explain why such a large share—an estimated nearly 71 percent—of cottonwood forest stands are mature or overmature. Invasive species such as Russian olive and saltcedar have also interfered with regeneration of cottonwood forests. They have invaded riparian woodlands across the Northern Great Plains and displaced the native vegetation, taken up water, and increased fire frequency (Larmer 1998, Shafroth et al. 1995, Sprenger 1999).

Public/private cooperation presents an opportunity for managing the cottonwood resource as 73 percent of all Northern Great Plains States cottonwood forests are in private hands. Active management includes harvesting, release of reservoir water to simulate natural flooding (Bradley and Smith 1986), and protection of seedlings from grazing by domestic animals (Crouch 1979). All of these management activities can have a positive effect on regeneration and growth of the cottonwood resource across the Northern Great Plains.

Field windbreak composed of green ash trees. Photo by Dacia Meneguzzo, USDA Forest Service.

Forest Products

Ponderosa pine in northwestern South Dakota. Photo by Dacia Meneguzzo, USDA Forest Service.

Growing-stock Volume

Background

Growing-stock volume is the amount of sound wood in live, commercial tree species. To be classified as growing stock, trees must be at least 5 inches in d.b.h. and free of defect. This measure has traditionally been used to determine wood volume available for commercial use. Estimates of the volume of growing stock are important considerations in economic planning and evaluations of forest sustainability.

What we found

The total growing-stock volume on Northern Great Plains States timberland is estimated at 4.5 billion cubic feet (Fig. 66), or an average of 737 cubic feet per acre of timberland, a decrease of about 60 cubic feet per acre compared to the 2010 inventory (Fig. 67). Most counties have a growing-stock density less than the regional average (Fig. 68). South Dakota has the most growing-stock volume at nearly 1.8 billion cubic feet, followed by Kansas (1.4 billion cubic feet), Nebraska (926 million cubic feet), and North Dakota (359 million cubic feet). Growing-stock volume has decreased since 2010 in South Dakota and since 2005 in Nebraska (Fig. 66). The 10 species with the greatest growing-stock volume on timberland account for 87 percent of all growing-stock volume: ponderosa pine, cottonwood, hackberry, green ash, bur oak, black walnut, American elm, northern red oak, white spruce, and quaking aspen (Fig. 69). Of these species, only five (cottonwood, hackberry, black walnut, white spruce, and quaking aspen) increased in growing-stock volume between 2010 and 2015.

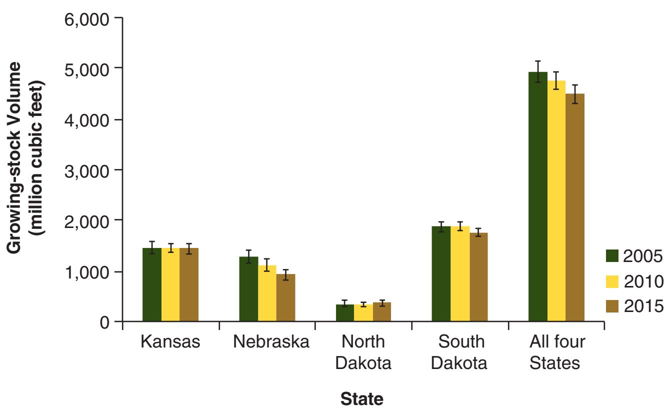


Figure 66.—Growing-stock volume on timberland by State and inventory year, Northern Great Plains States. Error bars show a 68 percent confidence interval around the mean.

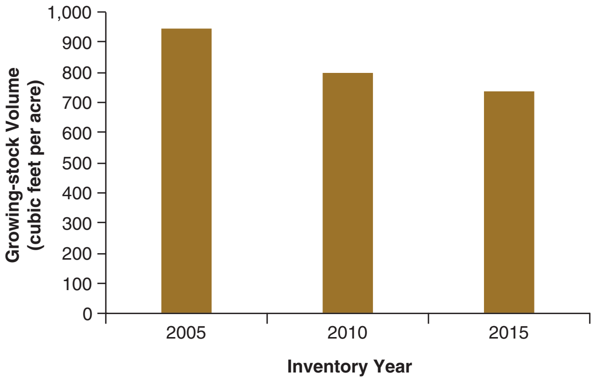


Figure 67.—Average growing-stock volume per acre of timberland by inventory year, Northern Great Plains States.

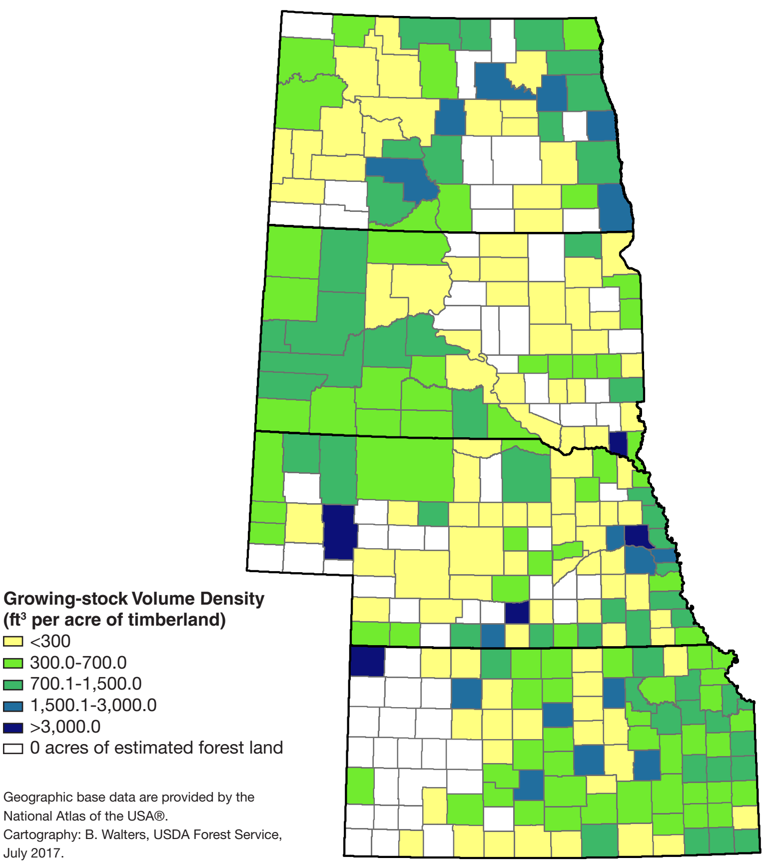


Figure 68.—Growing-stock volume density on timberland by county, Northern Great Plains States, 2015.

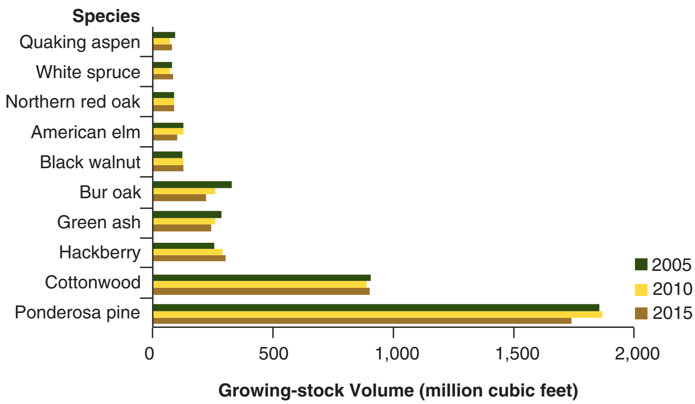


Figure 69.—Growing-stock volume on timberland for the 10 most voluminous species by inventory year, Northern Great Plains States.

What this means

The decrease in growing-stock volume is due in part to the age structure of many forest stands as well as a variety of biotic and abiotic factors such as drought, flooding, fire, and insect outbreaks. These stressors have contributed to increases in mortality and trees with poor form, resulting in decreased growing-stock volume. The losses in volume for commercial species indicate potential problems for sustainability of economically important forest resources, which should be monitored into the future. In addition, declines in major species may lead to changes in future species composition.

Sawtimber Quantity and Quality

Background

Sawtimber trees are live trees of commercial species that contain either a 12-foot log or two noncontiguous 8-foot logs that are free of defect. To qualify as sawtimber, softwood trees must be at least 9.0 inches d.b.h. and hardwoods must be at least 11.0 inches d.b.h. 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 (7 inches for softwoods and 9 inches for hardwoods). Estimates of sawtimber volume, expressed as board feet (International ¼-inch rule), are used to determine the monetary value of wood volume and to identify the quantity of merchantable wood available.

The quality of live sawtimber volume is rated by using three tree grades, based on diameter and the presence or absence of defects such as knots, decay, and curvature of the bole. Grade 1 indicates the highest quality. Softwood sawtimber is valued primarily for lumber, whereas hardwood sawtimber is valued for other products such as flooring and furniture.

What we found

Sawtimber volume is estimated at 17.6 billion board feet across the Northern Great Plains States timberlands, a decrease of about 2 percent between 2010 and 2015 (Fig. 70). Average sawtimber volume per acre of timberland is 2,890 board feet, a decrease of 133 board feet per acre since 2010. Five species—ponderosa pine, cottonwood, hackberry, bur oak, and green ash—account for 79 percent of the sawtimber volume on timberland in the Northern Great Plains States (Fig. 71). Even though these species account for the majority of sawtimber volume, bur oak, ponderosa pine, and green ash decreased in total sawtimber volume on forest land between 2010 and 2015 (Fig. 72).

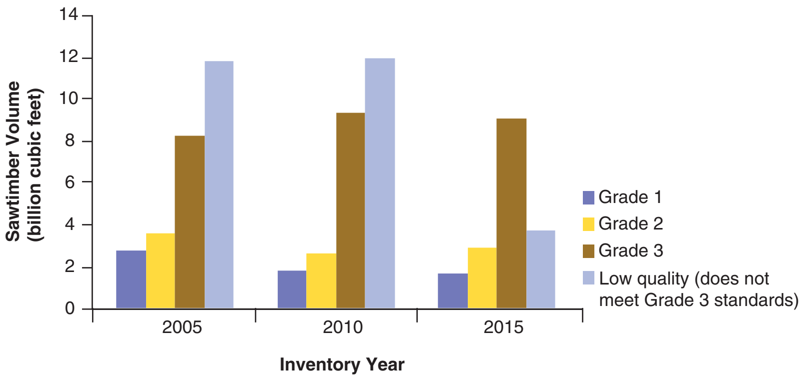


Figure 70.—Sawtimber volume (board feet, International ¼-inch rule) on timberland by grade and inventory year, Northern Great Plains States.

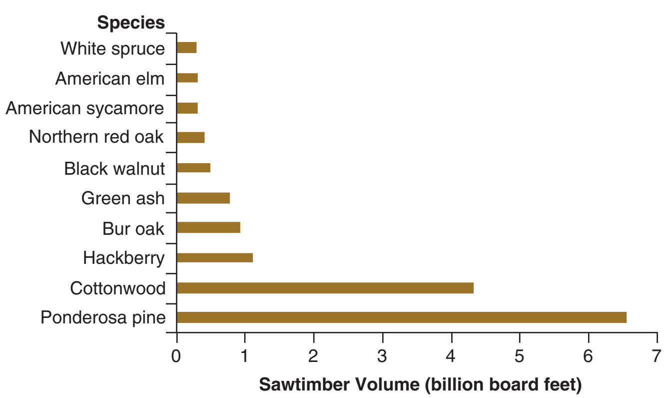


Figure 71.—Sawtimber volume of the 10 species with the highest sawtimber volume on timberland, Northern Great Plains States, 2015.

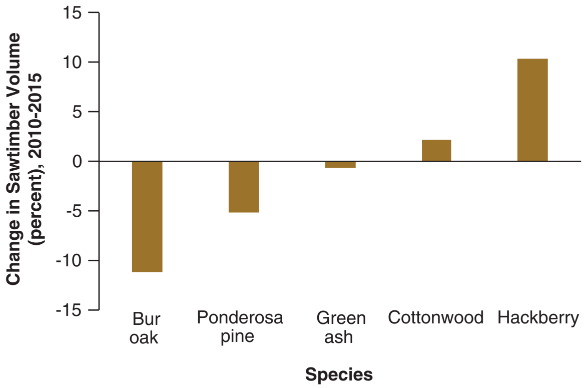


Figure 72.—Percentage change in sawtimber volume for the five species with the highest sawtimber volume, Northern Great Plains States, 2010-2015.

What this means

The volume of sawtimber is decreasing for some species, such as bur oak, ponderosa pine, green ash, and American elm. Insect outbreaks are partly responsible for this decrease in volume. For example, high mortality rates caused by the bark beetle infestation explains much of the decrease in the volume of ponderosa pine. Cottonwood, hackberry, black walnut, silver maple, and other species are gaining sawtimber volume. Although sawtimber volume declined by a small percentage between inventories, we would expect a slow but steady increase in sawtimber volume as younger forests continue to grow and mature across the Northern Great Plains States over the coming decades.

Growing-stock Stocking and Stand-size Class

Background

Growing-stock stocking information describes the degree of occupancy of land by growing-stock trees compared with a desired level for balanced health and growth. Growing-stock stocking levels are calculated from the number of trees, species, sizes, and spacing. A fully stocked stand indicates full utilization of the site. In stands of trees 5.0 inches d.b.h. and larger, a fully stocked stand would typically have a basal area of more 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 80 square feet per acre when the trees are at least 5.0 inches in diameter.

Stand-size class is a measure of the average diameter of the dominant trees in a stand. There are three stand-size classes: 1) Large diameter stands are those where a plurality of stocking is in hardwoods with a d.b.h. of 11.0 inches or more and softwoods with a d.b.h. of 9.0 inches or more; 2) medium diameter stands occur where a plurality of stocking is in softwood trees from 5.0 to 9.0 inches d.b.h. and hardwood trees from 5.0 to 11.0 inches d.b.h.; and 3) small diameter stands (seedling-sapling size stands) are those in which a plurality of stocking is in trees less than 5.0 inches d.b.h. Tracking change in the distribution of stand-size class provides information about forest sustainability and succession, and forests' potential for wood products, wildlife habitat, and recreation opportunities.

What we found

In terms of growing-stock stocking, most (71 percent) of the Northern Great Plains States forest land is classified as poorly stocked or nonstocked; only 6 percent is fully stocked (Fig. 73). With regard to stand-size class, more than half (53 percent) of the region's forest land area is made up of large diameter stands. The total area of large diameter and small diameter stands in the Northern Great Plains States increased between 2005 and 2015 (Fig. 74), but the proportion of forest land in large diameter or small diameter stands has fluctuated by state during this time period (Fig. 75). In South Dakota, for example, while the proportion in small diameter stands grew from 12 percent to 17 percent, the proportion in large diameter stands fell from 64 percent to 60 percent. Currently, large diameter stands contain more than half (55 percent) of all fully stocked stands. However, two-thirds of large diameter stands have poor stocking or are considered nonstocked. Medium diameter stands make up 23 percent of forest land and have even poorer stocking: 87 percent of this acreage is poorly stocked or nonstocked. Small diameter stands make up the least amount of forest land area (18 percent) and contain the least area of nonstocked forest land (Fig. 76). Stocking levels also vary among the different forest types (Fig. 77). More than 2.8 million acres, or 41 percent of forest land acreage in the Northern Great Plains States, have a basal area of more than 80 square feet per acre, and 30 percent of forest land acreage has a basal area between 41 and 80 percent (Figs. 78 and 79).

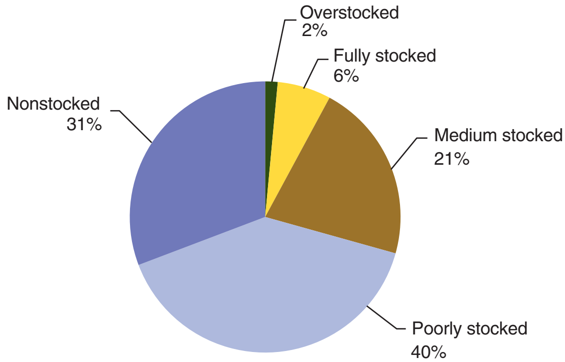


Figure 73.—Proportion of Northern Great Plains forest land by stocking level, 2015.

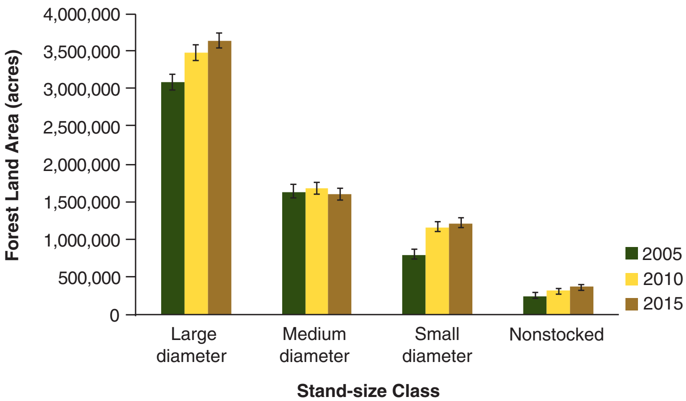


Figure 74.—Forest land area by stand-size class and inventory year, Northern Great Plains States. Error bars show a 68 percent confidence interval around the mean.

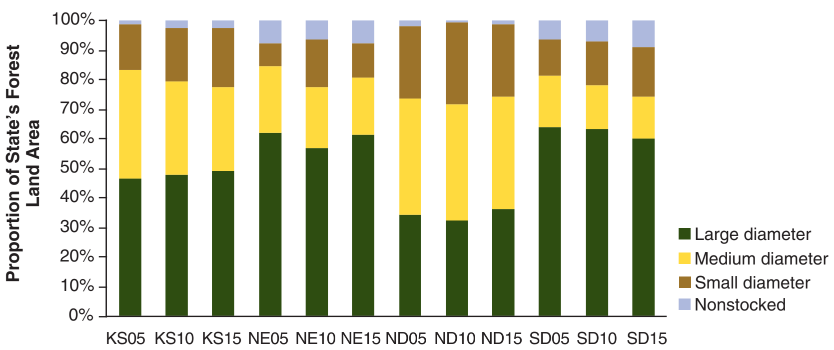


Figure 75.—Proportion of forest land area by State (KS = Kansas, NE = Nebraska, ND = North Dakota, and SD = South Dakota), stand-size class, and inventory year (05 = 2005; 10 = 2010; 15 = 2015).

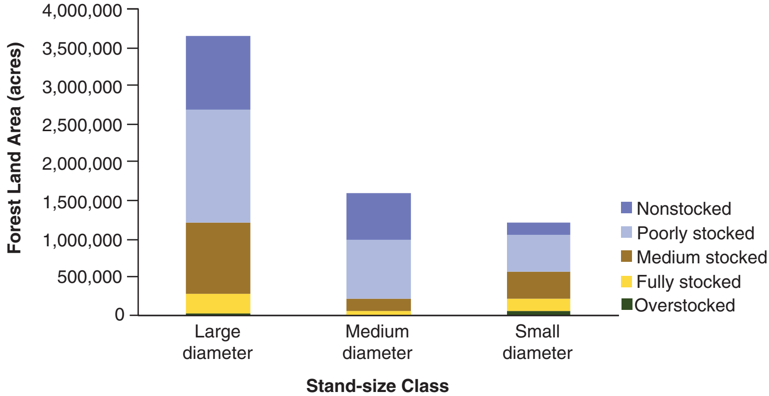


Figure 76.—Forest land by stand-size class and stocking level, Northern Great Plains States, 2015.

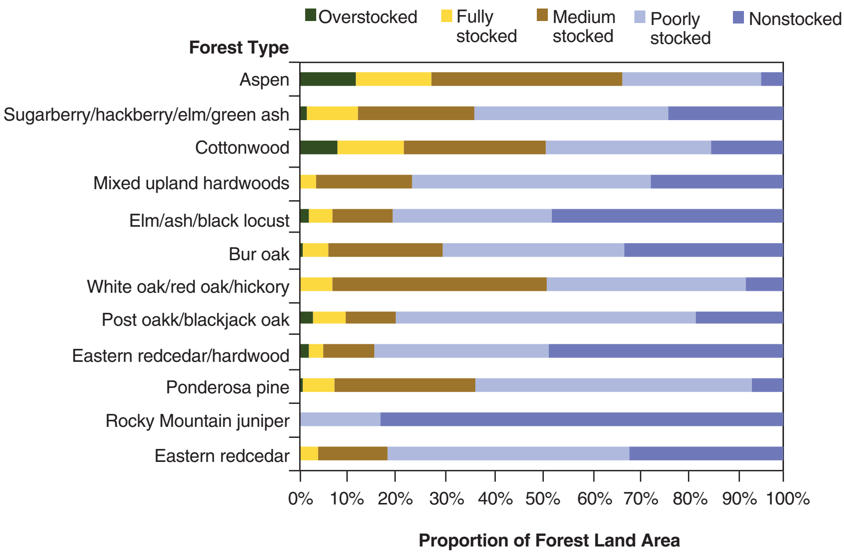


Figure 77.—Proportion of forest land area by stocking class for 12 selected forest types or forest-type groups, Northern Great Plains States, 2015.

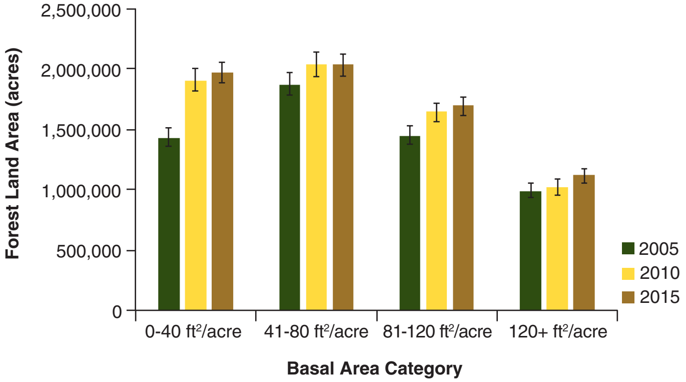


Figure 78.—Forest land area by category of all live basal area and inventory year, Northern Great Plains States. Error bars show a 68 percent confidence interval around the mean.

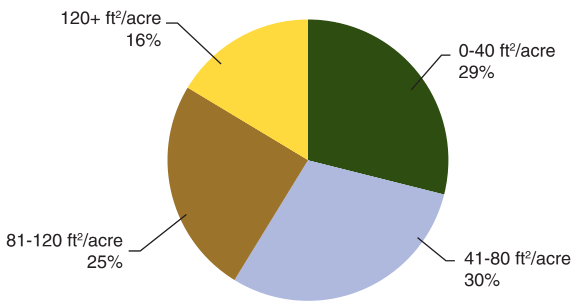


Figure 79.—Proportion of forest land by all live basal area, Northern Great Plains States, 2015.

What this means

The density and size of stands across the Northern Great Plains States provide information on the stages of stand development and forest growing-stock stocking levels for management purposes. Determining stages of stand development aids in projecting the future growth and mortality of the forest resources and can help guide future forest management objectives. For example, the high proportion of older, large diameter cottonwood stands points to problems with cottonwood regeneration and the need for active management to promote cottonwood regeneration.

Timber Products Output

Background

The harvesting and processing of timber products produce a stream of income shared by timberland owners, managers, marketers, loggers, truckers, and processors. The wood products and paper manufacturing industries employed 10,000 people in Kansas, Nebraska, North Dakota, and South Dakota in 2012, with a total value of shipments of $2.8 billion (U.S. Census Bureau n.d.). To better manage the forests of the Northern Great Plains, it is important to know the species, amounts, and locations of timber being harvested.

Surveys of wood-processing mills in Kansas, Nebraska, North Dakota, and South Dakota are conducted periodically to estimate the amount of wood volume that is processed into products. Information collected is supplemented with the most recent surveys conducted in surrounding states that processed wood harvested from these States. The active primary wood processing mills in Nebraska, North Dakota, and South Dakota were surveyed in 2014, and in Kansas in 2015, to determine the species that were processed and where the wood material came from.

What we found

There were 37 active primary forest products mills in Kansas, which reported processing 4.0 million board feet of saw logs. The 42 active forest product mills in Nebraska processed 10.7 million board feet of saw logs and 774,000 cubic feet of other products. There were only seven active forest product mills in North Dakota, and they reported a total of 609,000 board feet of saw logs processed. The 19 active forest products mills in South Dakota processed 88.9 million board feet of saw logs and 10.3 million cubic feet of other products. Eighty-four percent of the volume processed by Northern Great Plains States wood-processing mills came from the four States. Most (94 percent) of the wood material imported into the region came from Wyoming and went to mills in South Dakota. Wood material from Indiana, Iowa, Kentucky, Minnesota, Missouri, Montana, and Oregon provided the remaining 6 percent of the imports.

A total of 2.1 million cubic feet of industrial roundwood (round sections cut from trees) was harvested in Kansas, 2.4 million cubic feet in Nebraska, 120,000 cubic feet in North Dakota, and 27.7 million cubic feet in South Dakota. Saw logs accounted for 71 percent of the total industrial roundwood harvested. The second largest volume harvested was for cabin logs, accounting for 16 percent of the volume (Fig. 80). Other products from harvested roundwood included pulpwood, posts and poles, industrial fuelwood, excelsior, veneer logs, and other miscellaneous products. Ponderosa pine (nearly all from South Dakota) was the species with the highest harvest volume, accounting for 85 percent of the total industrial roundwood harvest. Cottonwood accounted for 6 percent of the total harvest, black walnut accounted for another 4 percent, and eastern redcedar accounted for 2 percent (Fig. 81). Total industrial roundwood harvest in the Northern Great Plains States increased by nearly 6 percent between 2009 and 2014, but only Kansas and South Dakota reported increases, 24 and 12 percent respectively (Fig. 82). Nebraska reported a decrease of 40 percent and North Dakota a decrease of 23 percent.

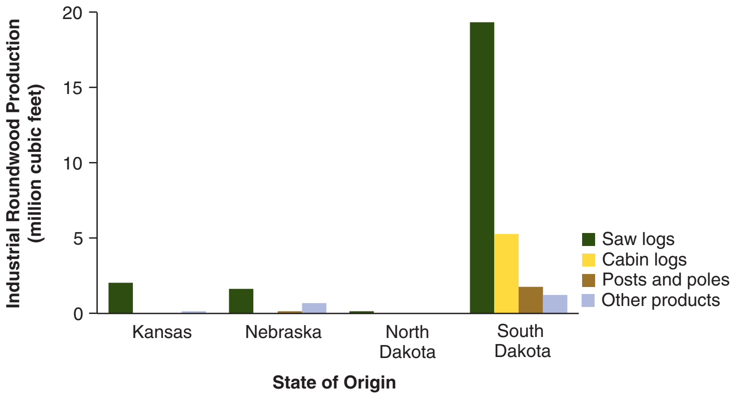


Figure 80.—Industrial roundwood production, by state of origin and products, Northern Great Plains States, 2014.

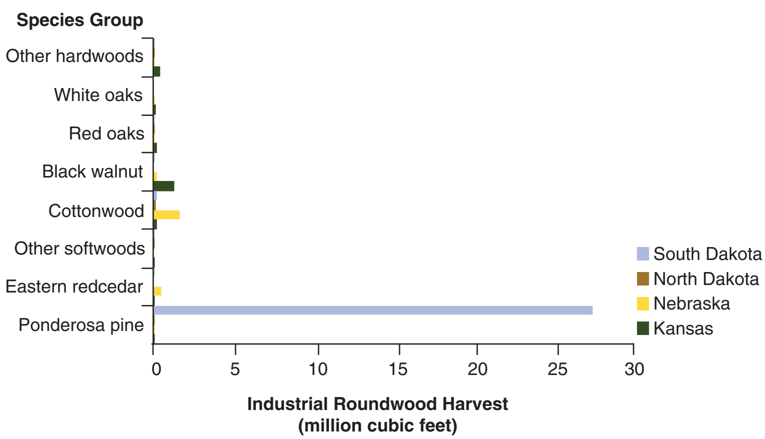


Figure 81.—Industrial roundwood harvest by species group and State, Northern Great Plains States, 2014.

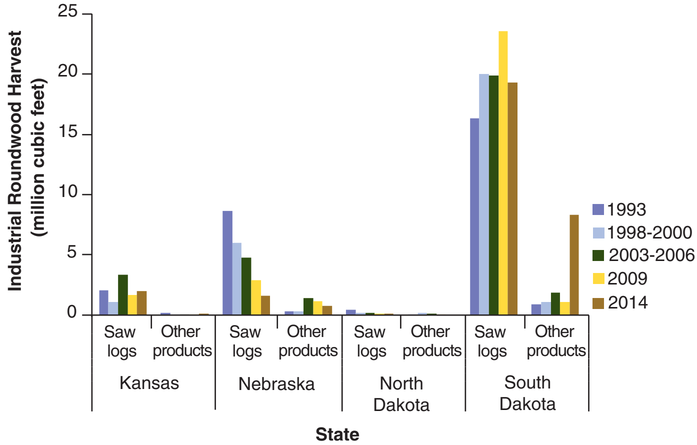


Figure 82.—Industrial roundwood harvest by product, State, and inventory year, Northern Great Plains States.

In the process of harvesting industrial roundwood in the Northern Great Plains States, 13.1 million cubic feet of harvest residue was left in the woods. Twenty percent of this volume was growing-stock material (logging residue), considered usable for products by FIA standards. The remaining 80 percent is nongrowing-stock material (logging slash), such as tops, limbs, and rotten sections, and is not considered usable for products by FIA standards. South Dakota, which has some harvest for pulpwood products, reported that only 17 percent of the harvest residues consisted of growing-stock material. In Kansas, which primarily harvested saw logs, more than one-third of the harvest residues was composed of growing-stock material (Fig. 83).

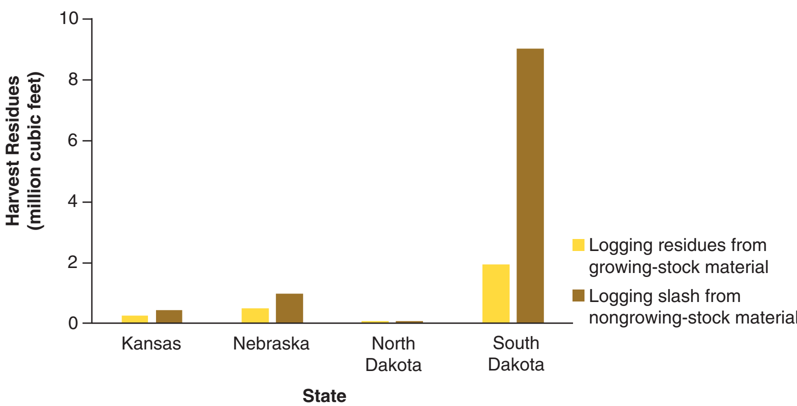


Figure 83.—Harvest residues generated by growing-stock and nongrowing-stock sources and State, Northern Great Plains States, 2014.

There were 380,000 green tons of mill residues produced at the Northern Great Plains States' primary wood-using mills in 2014. South Dakota generated the largest amount of mill residues with 329,000 green tons, followed by Nebraska with 40,000 green tons, Kansas with 10,000 green tons, and North Dakota with 2,000 green tons. More than one-third of the mill residues was sent to mills for use in making pulp or composite panels (Fig. 84). Other important uses for the mill residues were mulch (17 percent of mill residues), pellets (12 percent), and industrial fuelwood (11 percent). Eighteen percent of the mill residues was not utilized. Nebraska had the lowest percentage of unused mill residues at 11 percent. Nineteen percent of South Dakota's mill residues, 34 percent of Kansas's, and nearly two-thirds of North Dakota's went unused.

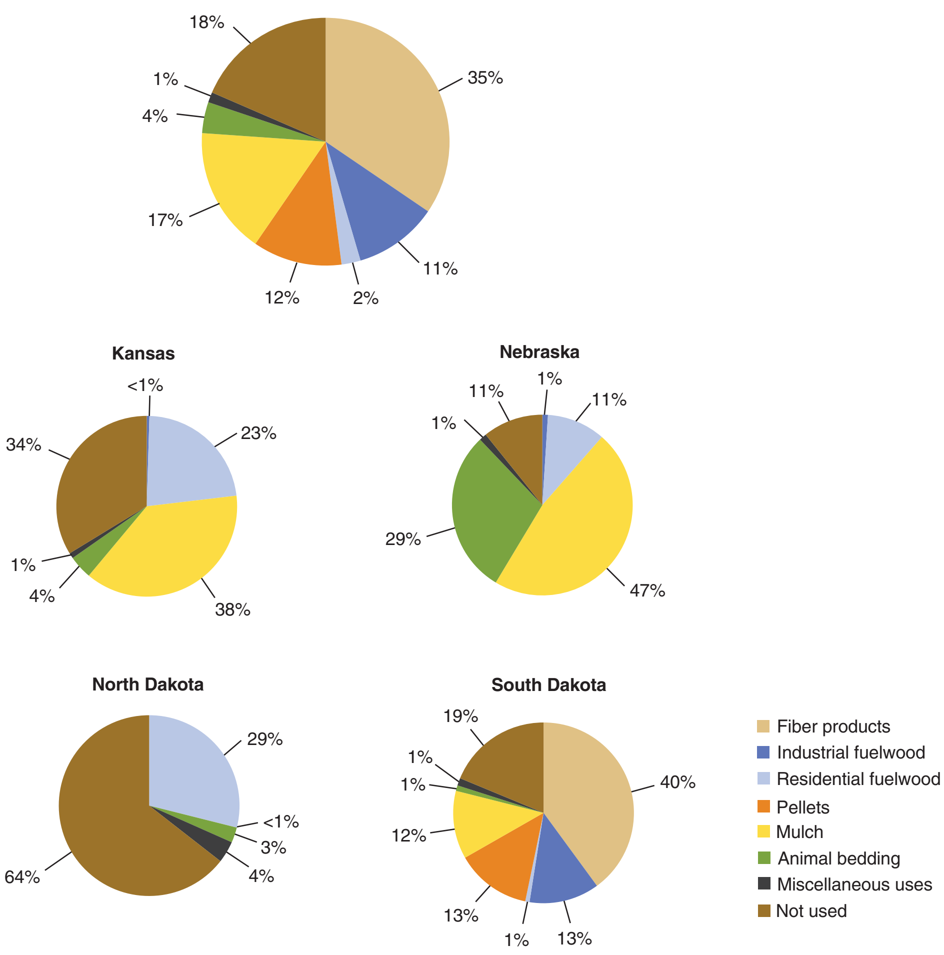


Figure 84.— Disposition of mill residues generated by primary wood-using mills by disposition and State, Northern Great Plains States, 2014.

What this means

The Northern Great Plains States forest products industry is for the most part a regional or local economy and does not have many mills that rely on the building or housing construction industry for markets for their products. For this reason, between 2003 and 2009, there was only a 3 percent decrease in harvesting of industrial roundwood in the Northern Great Plains States as a whole, while other regions of the country experienced decreases of 30 to 40 percent. The Northern Great Plains States do not all show the same trends in industrial roundwood harvesting, however. Nebraska and North Dakota have had a continuous trend of decreasing industrial roundwood harvesting since 1993. Industrial roundwood harvesting in Kansas has fluctuated, more closely following the market, and in South Dakota, it has continued to rise since 1993.

There was an estimated 8.5 billion cubic feet of wood material in live trees (5 inches d.b.h. or greater) on the forest land of the Northern Great Plains States in 2014. Average annual harvest removals of live trees on forest land at 71.2 million cubic feet was less than 1 percent of the total volume. South Dakota, which has the most harvesting of the four States, averaged removals of 1.5 percent of the total live-tree volume between 2010 and 2014. Average annual net growth of live trees on forest land is outpacing average annual harvest removals at a rate greater than 2.5 to 1. Only South Dakota, which has a high loss of volume due to mortality, has harvest removals greater than net growth. North Dakota has a greater than 30 to 1 ratio of net growth to removals. These ratios indicate a potential to increase the harvest of forest products in the Northern Great Plains States. Many areas have the resources but not the infrastructure to process the material. Small local mills that process forest products for the local or regional economy would make the most sense for these scattered resources.

Data Sources and Techniques

Forest Inventory

Information on the condition and status of forests in the Northern Great Plains States was obtained from the Northern Research Station's Forest Inventory and Analysis (NRS-FIA) program. Previous inventories of Northern Great Plains States forest resources can be found in Table 8. Data from Northern Great Plains States forest inventories can be accessed online at https://www.nrs.fs.fed.us/fia. For detailed information on inventory methods, see the "Statistics, Methods, and Quality Assurance" section online at https://doi.org/10.2737/NRS-RB-116 and Gormanson et al. (2018).

Table 8.—Previous forest inventories of the Northern Great Plains States

Kansas

- 1936 (Kansas State College 1939)
- 1965 (Chase and Strickler 1968)
- 1981 (Spencer et al. 1984)
- 1994 (Leatherberry et al. 1999)
- 2005 (Moser et al. 2008)
- 2010 (Moser et al. 2013)

Nebraska

- 1955 (Stone and Bagley 1961)
- 1983 (Raile 1986)
- 1994 (Schmidt and Wardle 1998)
- 2005 (Meneguzzo et al. 2008)
- 2010 (Meneguzzo et al. 2012)

North Dakota

- 1954 (Warner and Chase 1956)
- 1980 (Jakes and Smith 1982)
- 1994 (Haugen et al. 1999)
- 2005 (Haugen et al. 2009)
- 2010 (Haugen et al. 2013)

South Dakota

- 1935 (Ware 1936)
- 1962 (Choate and Spencer 1969)
- 1977 Western South Dakota only (Green 1978)
- 1984 (Collins and Green 1988)
- 1996 Forest land outside the Black Hills National Forest was surveyed in 1996 (Leatherberry et al. 2000); the Black Hills National Forest was surveyed in 1999 (DeBlander 2002)
- 2005 (Piva et al. 2009)
- 2010 (Piva et al. 2013)

National Woodland Owner Survey

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

Timber Products Output Inventory

Using a questionnaire designed to determine the size and composition of Northern Great Plains States forest product industries, the use of roundwood (round sections cut from trees), and the generation and disposition of wood residues, NRS-FIA or State agency personnel contacted via mail and telephone all primary wood-using mills in the region. Completed questionnaires were sent to NRS-FIA for processing. As part of data processing, all industrial roundwood volumes reported were converted to standard units of measure by using regional conversion factors.

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Appendixes

Appendix 1.—Tree species measured on Forest Inventory and Analysis plots, Northern Great Plains States, 2015

Common name	Scientific name
ailanthus	*Ailanthus altissima*
American basswood	*Tilia americana*
American elm	*Ulmus americana*
American plum	*Prunus americana*
American sycamore	*Platanus occidentalis*
apple spp.	*Malus* spp.
Austrian pine	*Pinus nigra*
balsam poplar	*Populus balsamifera*
Bebb willow	*Salix bebbiana*
bitternut hickory	*Carya cordiformis*
black ash	*Fraxinus nigra*
black cherry	*Prunus serotina*
black hickory	*Carya texana*
black locust	*Robinia pseudoacacia*
black oak	*Quercus velutina*
black walnut	*Juglans nigra*
black willow	*Salix nigra*
blackjack oak	*Quercus marilandica*
blue ash	*Fraxinus quadrangulata*
boxelder	*Acer negundo*
bur oak	*Quercus macrocarpa*
cherry and plum spp.	*Prunus* spp.
chinkapin oak	*Quercus muehlenbergii*
chittamwood, gum bumelia	*Sideroxylon lanuginosum*
chokecherry	*Prunus virginiana*
common persimmon	*Diospyros virginiana*
downy hawthorn	*Crataegus mollis*
eastern cottonwood	*Populus deltoides*
eastern hophornbeam	*Ostrya virginiana*
eastern redbud	*Cercis canadensis*
eastern redcedar	*Juniperus virginiana*
eastern white pine	*Pinus strobus*
green ash	*Fraxinus pennsylvanica*
hackberry	*Celtis occidentalis*

(Appendix 1 continued on next page.)

(Appendix 1 continued)

Common name	Scientific name
hawthorn spp.	*Crataegus* spp.
honeylocust	*Gleditsia triacanthos*
jack pine	*Pinus banksiana*
Kentucky coffeetree	*Gymnocladus dioicus*
mockernut hickory	*Carya alba*
northern catalpa	*Catalpa speciosa*
northern red oak	*Quercus rubra*
Norway spruce	*Picea abies*
Ohio buckeye	*Aesculus glabra*
Osage-orange	*Maclura pomifera*
overcup oak	*Quercus lyrata*
paper birch	*Betula papyrifera*
pawpaw	*Asimina triloba*
peachleaf willow	*Salix amygdaloides*
pecan	*Carya illinoinensis*
pin cherry	*Prunus pensylvanica*
pin oak	*Quercus palustris*
ponderosa pine	*Pinus ponderosa*
post oak	*Quercus stellata*
prairie crab apple	*Malus ioensis*
quaking aspen	*Populus tremuloides*
red mulberry	*Morus rubra*
red pine	*Pinus resinosa*
Rocky Mountain juniper	*Juniperus scopulorum*
Russian olive	*Elaeagnus angustifolia*
saltcedar	*Tamarix* spp.
Scotch pine	*Pinus sylvestris*
serviceberry spp.	*Amelanchier* spp.
shagbark hickory	*Carya ovata*
shellbark hickory	*Carya laciniosa*
shingle oak	*Quercus imbricaria*
Shumard oak	*Quercus shumardii*
Siberian elm	*Ulmus pumila*
silver maple	*Acer saccharinum*
slippery elm	*Ulmus rubra*
southern catalpa	*Catalpa bignonioides*
sugar maple	*Acer saccharum*
sugarberry	*Celtis laevigata*

(Appendix 1 continued on next page.)

(Appendix 1 continued)

Common name	Scientific name
Texas buckeye	*Aesculus glabra arguta*
western soapberry	*Sapindus saponaria drummondii*
white ash	*Fraxinus americana*
white mulberry	*Morus alba*
white oak	*Quercus alba*
white spruce	*Picea glauca*
white willow	*Salix alba*
willow spp.	*Salix* spp.

Appendix 2.—Invasive plant species monitored on Forest Inventory and Analysis P2 invasive plots. An asterisk indicates species found in the inventory, Northern Great Plains States, 2015

Tree Species	
*black locust	(*Robinia pseudoacacia*)
chinaberry	(*Melia azedarach*)
Chinese tallow	(*Triadica sebifera*)
Norway maple	(*Acer platanoides*)
princesstree	(*Paulownia tomentosa*)
punktree	(*Melaleuca quinquenervia*)
*Russian olive	(*Elaeagnus angustifolia*)
saltcedar	(*Tamarix ramosissima*)
*Siberian elm	(*Ulmus pumila*)
silktree	(*Albizia julibrissin*)
tree of heaven	(*Ailanthus altissima*)

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

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

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

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

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The 2015 inventory of the forests of the Northern Great Plains States (Kansas, Nebraska, North Dakota, and South Dakota) reports more than 6.8 million acres of forest land and almost 2.2 billion trees. Forest land is dominated by the ponderosa pine and sugarberry/hackberry/elm/green ash forest types, which together occupy one-third of the total forest land area. The volume of growing stock on timberland currently totals 4.6 billion cubic feet. The average annual net growth of live trees from 2010 to 2015 was nearly 157 million cubic feet per year. This report includes additional information on forest attributes, carbon, timber products, and forest health. The following information is available online at https://doi.org/10.2737/NRS-RB-116: 1) descriptive information on forest inventory statistics, methods, and quality assurance of data collection; 2) tables that summarize quality assurance; 3) a core set of tabular estimates for a variety of forest resources; and 4) a Microsoft® Access database that represents an archive of data used in this report, with tools that allow users to produce customized estimates.

KEY WORDS: inventory, forest statistics, forest land, trees outside forests, volume, biomass, carbon, growth, removals, mortality, forest health, Kansas, Nebraska, North Dakota, South Dakota

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