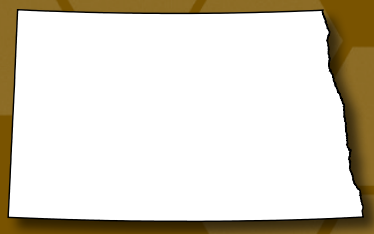
North Dakota's Forests 2010



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Forest Service

Abstract

The second annual inventory of North Dakota's forests reports more than 772,000 acres of forest land with an average volume of more than 921 cubic feet per acre. Forest land is dominated by the bur oak forest type, which occupies more than a third of the total forest land area. The poletimber stand-size class represents 39 percent of forest land, followed by sawtimber (32 percent) and saplings/seedlings (28 percent). The volume of growing stock currently totals more than 341 million cubic feet. The average annual net growth of growing stock on forest land from 2006 to 2010 was approximately 6.8 million cubic feet per year. This report includes additional information on forest attributes, land use change, carbon stocks, timber products, forest health, and statistics and quality assurance of data collection. Detailed information on forest inventory methods and data quality estimates is included in a DVD at the back of this report. Tables of population estimates and a glossary are also included.

Acknowledgments

The authors would like to thank the many individuals who contributed both to the inventory and analysis of North Dakota's forest resources. Primary field crew and QA staff over the 2006-2010 field inventory cycle included Todd Bixby, James Blehm, Dan Huberty, Brent Hummel, Dan Kaisershot, Cassandra Kurtz, Mike Maki, Grant Nielsen, Greg Pugh, Kirk Ramsey, Earl Sheehan, and Joel Topham.

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Cover: Bottomland forest along the Red River, near Hickson, ND. Photo by Robert Harsel, North Dakota Forest Service, used with permission.

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North Dakota's Forests 2010

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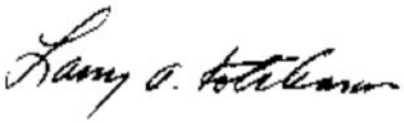
Foreword

We welcome you to read the latest results of our statewide forest inventory, North Dakota's Forests 2010. The inventory and report are products of a cooperative effort between the North Dakota Forest Service and the Forest Inventory and Analysis program of the U.S. Forest Service.

North Dakota's 772,000 acres of forests provide wildlife habitat, recreational opportunities, and wood products; stabilize river banks; filter water runoff from adjacent agricultural lands; serve as seed sources for conservation tree production; and contribute to the botanical diversity of the State.

Private landowners hold 68 percent of the State's forest land and State and Federal agencies the remaining 32 percent. Both ownership groups play an important role in the State's natural resource heritage. North Dakota's forests are robust; however, threats to these important resources exist. Invasive species, conversion of forests to other land uses, over-maturity of existing stands, and suppression of natural disturbances essential to regenerate forests are issues that will require attention.

Society demands a wide array of goods and services from our forests. North Dakota's Forests 2010 provides a common set of statistically accurate estimates that can be used to make sound forest management decisions. We invite you to read the results of North Dakota's Forests 2010 and participate in the discussions about the future of forests and forestry in our State.



Larry Kotchman
North Dakota State Forester

Contents

Highlights

On the Plus Side

- Forest land accounts for 772,000 acres or 1.6 percent of the land area in North Dakota. Sixty-nine percent of North Dakota's forests are classified as timberland.
- The area of forest land has increased by 6.6 percent (48,200 acres) since 2005.
- The total oven-dry biomass (short tons) of all live trees on forest land increased slightly from 18.2 million tons in 2005 to 18.3 million tons in 2010. That is an average of 23.7 tons per acre of aboveground biomass.
- Sawtimber volume on timberland has increased by 5 percent, totaling 1.183 billion board feet in 2010.
- On average, there are 442 trees per acre on forest land in the State.
- In North Dakota, an average of 16 standing dead trees per acre on forest land provide valuable wildlife habitat.
- Fuel loadings of down wood materials are not exceedingly high in North Dakota compared to western states.

Issues to Watch

- Ash trees, an important component of North Dakota's forests, windbreaks, and urban areas, are vulnerable to future emerald ash borer infestations and need to be monitored.
- Forty-five percent of the forest land in North Dakota is less than fully stocked. One-third of the forest land has medium stocking, 11 percent is poorly stocked, and 1 percent is nonstocked.
- The average annual mortality of growing stock on timberland from 2005 to 2010 was 6.5 million cubic feet; this is equal to 1.9 percent of the total growing-stock volume on timberland in 2010 compared to the 1.4 percent reported in 1994.
- High mortality rates have led to an 8 percent decline in overall growing-stock volume on forest land.
- Sixty-seven introduced or invasive plant species were found on 184 vegetation diversity plots in North Dakota. Forty-five percent of the plots had nonnative species.

Farmstead trees in winter. Photo by Aaron Bergdahl, North Dakota Forest Service, used with permission.

Background

Ponderosa pine/Rocky Mountain juniper in Badlands, ND. Photo by Robert Harsel, North Dakota Forest Service, used with permission.

A Beginners Guide to Forest Inventory

What is a tree?

We know a tree when we see one and we can agree on some common tree attributes. Trees are perennial woody plants with central stems and distinct crowns. In general, the Forest Inventory and Analysis (FIA) program of the U.S. Department of Agriculture, Forest Service defines a tree as any perennial woody plant species that can attain a height of 15 feet at maturity. In North Dakota, the problem is in deciding which species should be classified as shrubs and which should be classified as trees. A complete list of the tree species measured in this inventory can be found in North Dakota's Forests 2010: Statistics, Methods, and Quality Assurance on the DVD in the inside back cover pocket of this bulletin.

What is a forest?

FIA defines forest land as land that is at least 10 percent stocked by trees of any size or formerly having had such tree cover and not currently developed for nonforest use. The area with trees must be at least 1 acre in size, and roadside, streamside, and shelterbelt strips must be at least 120 feet wide to qualify as forest land.

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 North Dakota, 69 percent of the forest land is timberland, 3 percent is reserved forest land, and 28 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 (most of the reserved forest land in North Dakota is in the Theodore Roosevelt National Park).

- 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.

Before 2001 only trees on timberland plots were measured in North Dakota. Therefore, while we can report volume on timberland for those inventories, we cannot report volume on forest land. Under the new annual inventory system, trees were measured on all forest land so forest volume estimates can be produced. Because these annual plots were remeasured upon completion of the second annual inventory in 2010, we are now able to report growth, removals, and mortality.

How many trees are in North Dakota?

There are about 342 million trees on North Dakota's forest land (give or take a few thousand) that are at least 1 inch in diameter as measured at 4.5 feet above the ground. We do not know the exact number because we measured only about 1 out of every 81,896 trees. In all, 4,176 trees 1 inches and larger were sampled on 186 forested plots.[1]

How do we estimate a tree's volume?

Forest inventories typically express volume in cubic feet, but the reader may be more familiar with cords (a stack of wood 8 feet long, 4 feet wide, and 4 feet high). A cord of wood contains approximately 79 cubic feet of solid wood and 49 cubic feet of bark and air.

Volume can be precisely determined by immersing a tree in a pool of water and measuring the amount of water displaced. Less precise, but much cheaper, is the method used by the North Central Research Station (which later merged with the Northeastern Research Station to become the Northern Research Station). Several

1 During the 2010 inventory of North Dakota (from 2006 to 2010), we measured one 1/6-acre plot for approximately every 6,000 acres of forest land.

hundred cut trees were measured by taking detailed diameter measurements along their lengths to accurately determine their volumes (Hahn 1984). Regression lines were then fit to these data by species group. Using these regression equations, we can produce individual-tree volume estimates based on species, diameter, and tree site index (Woodall et al. 2011).

The same method was used to determine sawtimber volumes. FIA reports sawtimber volumes in ¼-inch International board-foot scale. Conversion factors for converting to Scribner board foot scale are also available (Smith 1991).

How much does a tree weigh?

The U.S. Forest Service's Forest Products Laboratory and others developed specific gravity estimates for a number of tree species (Miles and Smith 2009). These specific gravities were then applied to tree volume estimates to derive estimates of merchantable tree biomass (the weight of the bole). To estimate live biomass, we have to add in the stump (Raile 1982) and limbs and bark (Heath et al. 2009, Woodall et al. 2011). We do not currently report the live biomass of roots or foliage.

Forest inventories report biomass as green or oven-dry weight. Green weight is the weight of a freshly cut tree; oven-dry weight is the weight of a tree with zero percent moisture content. On average, 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 measure the carbon in standing trees, let alone carbon in belowground pools. FIA assumes that half the biomass in standing live/dead trees consists of carbon. The remaining carbon pools (e.g., soil, understory vegetation, belowground biomass) are modeled based on stand/site characteristics (e.g., stand age and forest type) (Smith et al. 2006).

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 FIA's ongoing efforts to improve the efficiency and reliability of the inventory, several changes in procedures and definitions have occurred since North Dakota's inventory in 1994. Although these changes will have little effect on statewide estimates of forest area, timber volume, and tree biomass, they may significantly affect plot classification variables such as forest type and stand-size class. Some of these changes make it inappropriate to directly compare annual inventories completed in 2005 and 2010.

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 are subject to changing laws, economic/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.

FIA endeavors to be precise in definitions and implementation. The program tries to minimize changes to these definitions and to collection procedures, but that is not always possible or desirable in a world of changing values and objectives. Although change is inevitable, we hope that through clarity and transparency forest inventory data will be of use to analysts for decades to come.

Forest Features

Theodore Roosevelt National Park. Photo by Aaron Bergdahl, North Dakota Forest Service, used with permission.

Forest Area

Background

North Dakota is often characterized as a prairie state due to the topography, soils, and climate that promote perennial grasses and forbs and limit the natural distribution of forest land. Although forests cover only 1.6 percent of the State's land (Fig.1), they are an extremely important component of the landscape. Forests are found scattered across the State in wood lots, along streams and river bottoms, within wooded draws of the western region, and in the hills of the north-central and northeastern regions.

What we found

North Dakota's forest land area is currently estimated at 772, 400 acres, a small increase of 48,200 acres since the last inventory in 2005 (see Haugen et al. 2009) (Fig. 2). Before this, forest land had decreased by 54,000 acres between the first (1954) (Warner and Chase 1956) and second (1980) inventories as a result of forest lands being shifted to agricultural uses (Jakes and Smith 1982).

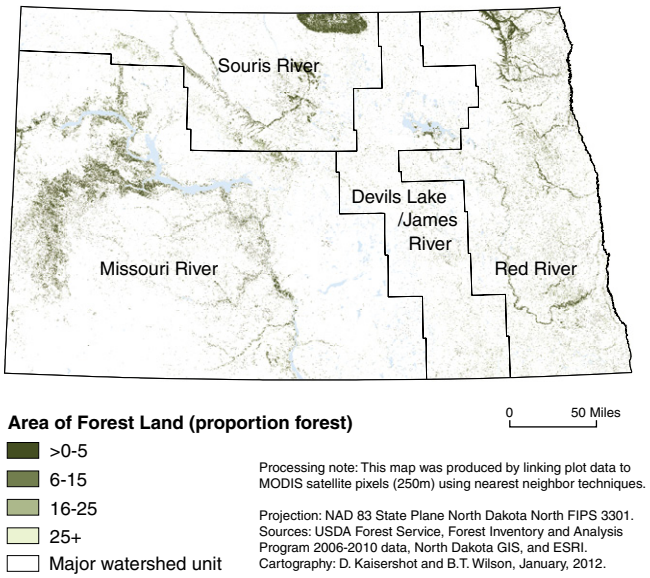


Figure 1.—North Dakota forest land area, 2010.

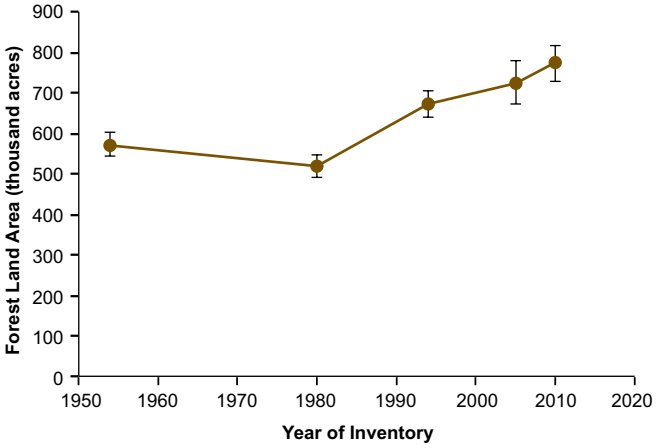


Figure 2.—Total forest land area and associated sampling errors, North Dakota, 1954-2010. Error bars show a 68 percent confidence interval.

What this means

At the State level, North Dakota's forest land area has been gradually increasing since the 1980s. Although the area of forest land is small compared to the entire land area, it is an important resource for multiple uses. Relatively large sampling errors are associated with the FIA inventory estimates at sub-state scales, so care should be taken when monitoring forest land area changes at these scales.

Forest Type Distribution

Background

North Dakota is unique in that the forest types found in the State occur at the geographic limits of many eastern and western forest types of the United States. Forest type distributions are largely determined by geology and climate. Forest types are a classification of forest land based on the species presently forming a plurality of the live-tree stocking. For example, forest land classified as the aspen/birch forest-type group is occupied primarily with aspen trees, but paper birch, balsam poplar, green ash, and bur oak trees can also be found within this type.

What we found

The oak/hickory forest-type group, inclusive of the specific bur oak forest type, is the dominant forest type of North Dakota's forest lands accounting for 39 percent or

298,000 acres of forest land area within the State (Fig. 3). Although the bur oak forest type grows throughout the State, 71 percent of this forest type is found within the Missouri River and Red River county groups. The elm/ash/cottonwood forest-type group accounts for 24 percent or roughly 182,000 acres. This type is generally found in low areas along rivers and streams throughout the State. The aspen/birch forest-type group accounts for 14 percent of all forest land in North Dakota. Most of the aspen/birch type (71 percent) is found in the Souris River county group, which contains the Turtle Mountains area of northern North Dakota. Softwood forest-type groups accounts for 12 percent of the forest land within the State. Rocky Mountain juniper, ponderosa pine, and spruce/fir (planted) forest-type groups accounts for roughly 90,000 acres of forest land in 2010.

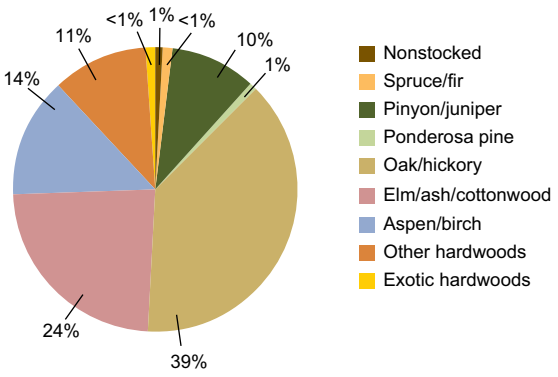
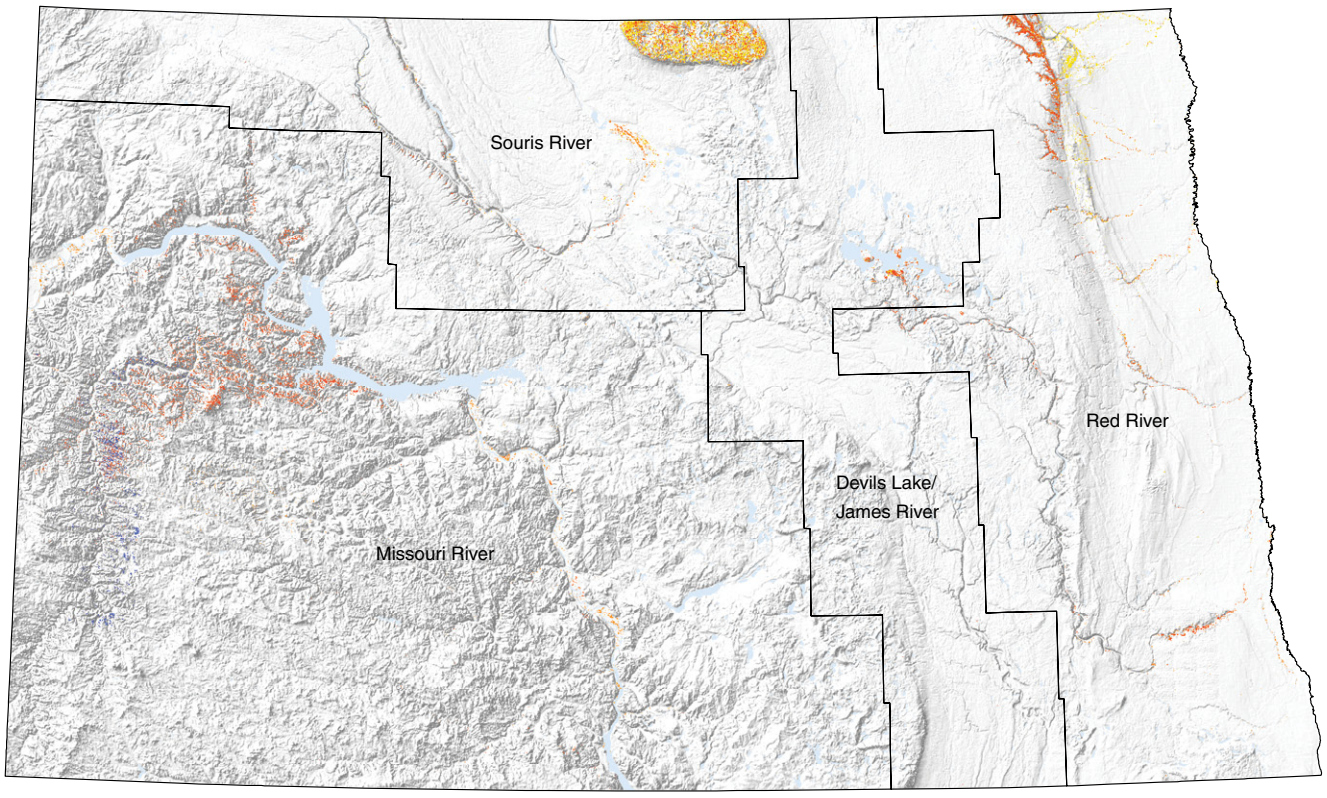


Figure 3.—Portion of forest land area by forest-type group, North Dakota, 2010.



Forest-type Group

- Nonforest
- Spruce/fir
- Pinyon/juniper
- Ponderosa pine
- Oak/hickory
- Elm/ash/cottonwood
- Aspen/birch
- Major watershed unit

0 50 Miles

Processing note: This map was produced by linking plot data to MODIS satellite pixels (250m) using nearest neighbor techniques.

Projection: NAD 83 State Plane North Dakota North FIPS 3301.
Sources: USDA Forest Service, Forest Inventory and Analysis Program 2006-2010 data, North Dakota GIS, and ESRI.
Cartography: D. Kaisershot and B.T. Wilson, January, 2012.

Figure 4.—Forest-type groups of North Dakota, 2010.

What this means

Hardwood forest types dominate the forest landscapes, accounting for 88 percent of all forest land in the State. Softwood forest types, primarily the Rocky Mountain juniper type, accounts for more than 10 percent of all softwood forest-type groups and is found scattered across the western part of the State (Fig. 4).

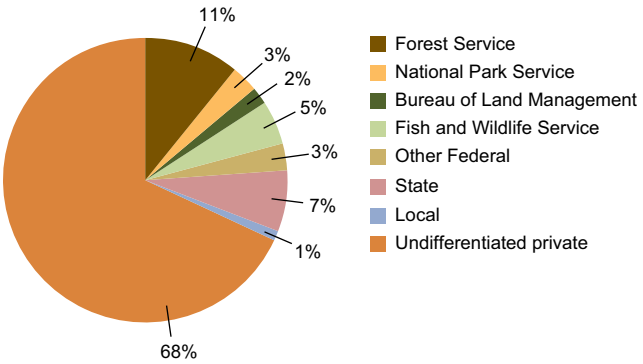


Figure 5.—Forest land by ownership or administering government unit, North Dakota, 2010.

Forest Ownership

Public Forests

Background

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

What we found

Nearly 32 percent of North Dakota's 772, 000 acres of forest land is in public ownership (Figs. 5, 6). The State of North Dakota administers 7 percent, local governments 1 percent, and the Federal government 24 percent. A large portion of Federal land is concentrated in the western part of the State on the Dakota Prairie Grassland and the Theodore Roosevelt National Park. Sixty-eight percent of North Dakota forest land is held in private ownership.

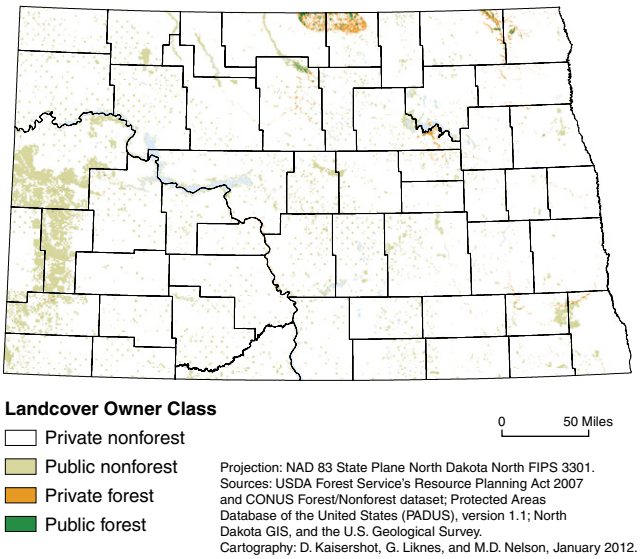


Figure 6.—Public and private forest land ownership, North Dakota, 2010.

What this means

Forest management objectives vary by owner. The North Dakota Forest Service manages forests for multiple benefits including water quality, forest products, wildlife, and recreation. Several Federal agencies manage areas available for cattle grazing or recreation (hiking, camping, bird watching, and fishing) many of which are forested or enhanced by trees. One of the most important factors throughout all forest management decisions in the State is the private landowner. Private landowners hold more than 527,000 acres of forest land. Their continued involvement and support of forest management programs is crucial.

Private Forest Owners

Background

The owners of the forest land ultimately control its fate and decide if and how it will be managed. By understanding forest owners, the forestry and conservation communities can better help the owners meet their needs, and in so doing, help conserve the region's forests for future generations. FIA conducts the National Woodland Owner Survey (NWOS) to better understand who owns the forests, why they own it, and how they use it (Butler 2008). Due to small samples for individual states, data for Kansas, Nebraska, North Dakota, and South Dakota are combined for this section.

What we found

Most forests across the Great Plains are privately owned, ranging from 95 percent of the forest area in Kansas to 29 percent in South Dakota (Fig. 7). Of these private acres, 91 percent are owned by families, individuals, and other unincorporated groups, collectively referred to as family forest owners.

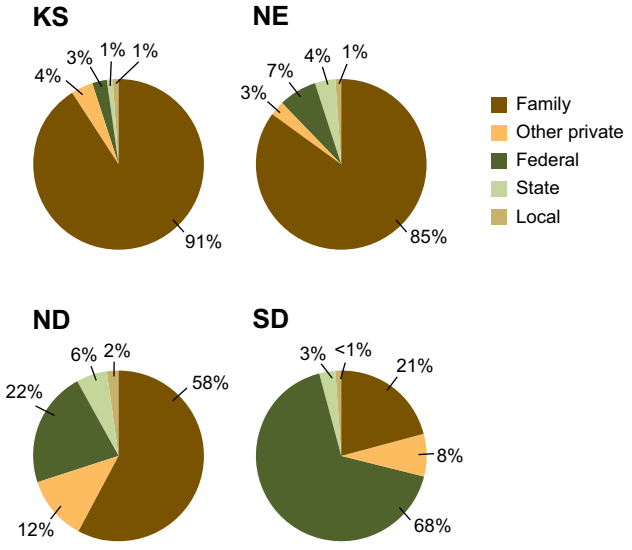


Figure 7.—Forest ownership, Kansas, Nebraska, North Dakota, and South Dakota, 2006.

A total of 191,000 family forest owners control 3.7 million forested acres across the region. Two-thirds of these owners have between 1 and 9 acres of forest land, but two-thirds of the forest land is in holdings of 50 acres or more (Fig. 8). The average holding size is 19 acres in Kansas, 20 acres in Nebraska, 18 acres in North Dakota, and 29 acres in South Dakota. The primary reasons for owning forest land are related to the land being part of the farm, aesthetics, family legacy, and protection of nature (Fig. 9).

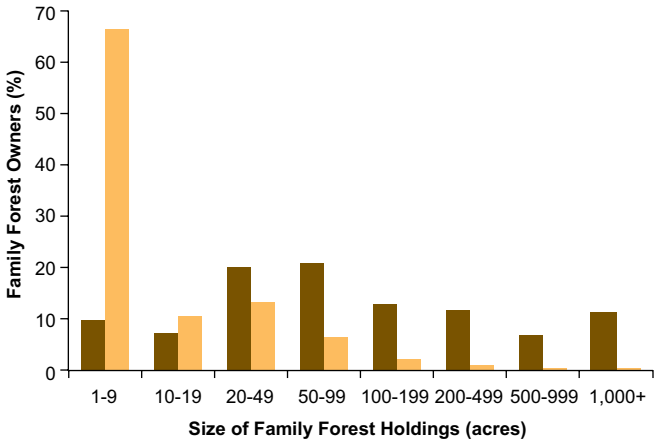


Figure 8.—Number of family forests in the Plain States and amount of forest land they own, by size of forest land holdings, Plain States, 2006.

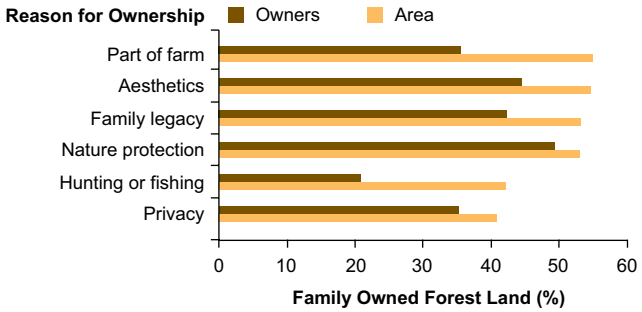


Figure 9.—Percent by area and number of family forests in the Plain States by reason for owning forest land, Plain States, 2006.

Although timber production is not a primary ownership objective for most owners, 25 percent of the family forest land is owned by people who have commercially harvested trees. Four percent of the land is owned by people who have a written management plan, and 20 percent of the land is owned by people who have received management advice.

What this means

Much of the land will soon be changing hands. One in six acres is owned by someone who plans to pass the land onto heirs or sell it in the near future. Family legacy is a major ownership objective and it is also a major concern. What can be done to help the forest owners and the land? It is clear that timber production is not on the forefront of forest owners' minds, but it is also clear that many owners are not adverse to harvesting and other activities in the woods. It is important to provide programs that meet the owners' needs.

Number of Tree and Size Distribution

Background

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

What we found

In North Dakota, there are an estimated 341.5 million trees on forest land, an average of 442 trees per acre. That works out to be 316 trees per acre less than 5 inches in diameter and 126 trees per acre more than 5 inches in diameter across all forest land (Figs. 10, 11).

Sapling-size trees (trees from 1 to 5 inches in diameter) account for 71.3 percent of the total number of trees growing on forest land. Poletimber-size trees (5 to 9 inches for softwoods and 5 to 11 inches for hardwoods) account for 23.3 percent and sawtimber-size trees account for the remaining 5.4 percent. Between 2005 and 2010, the total number of trees on forest land decreased slightly by an estimated 4.7 million or 1.4 percent: saplings decreased by 3 percent, while poletimber-size trees and sawtimber-size trees increased by 3 and 5 percent, respectively (Fig. 12).

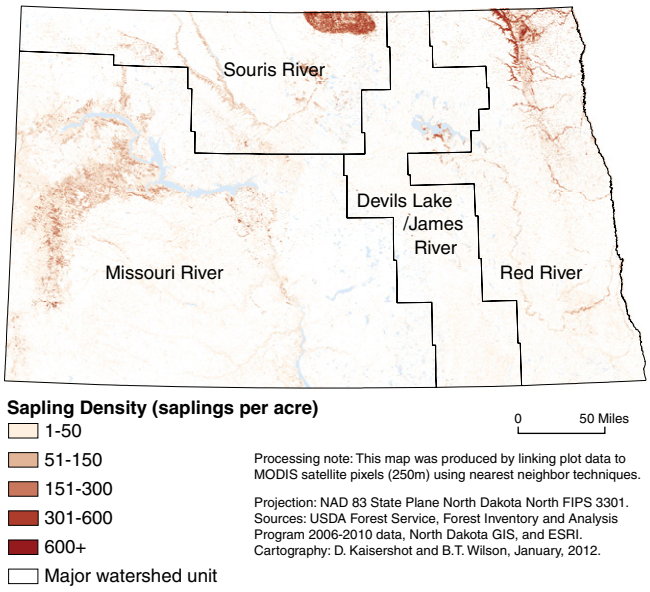


Figure 10.—Density of saplings (trees <5 inch) on forest land, North Dakota, 2010.

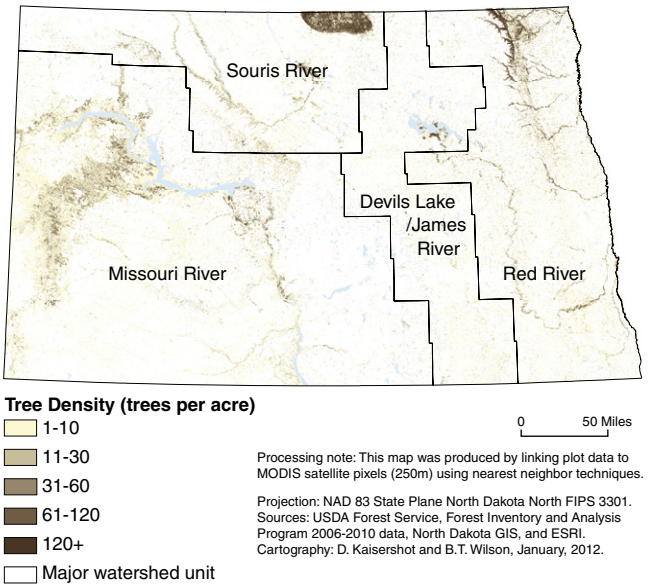


Figure 11.—Density of trees (>5 inch) on forest land, North Dakota, 2010.

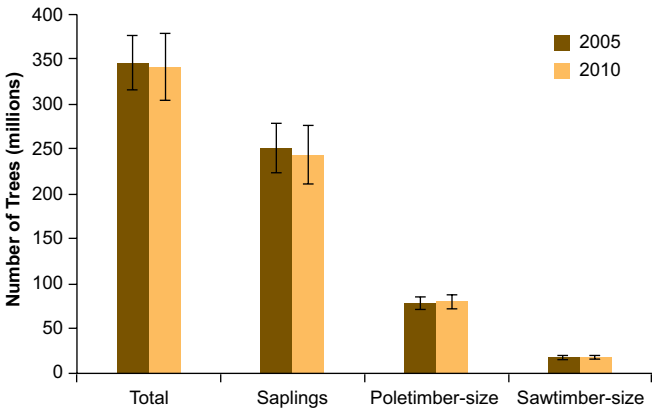


Figure 12.—Number of all live trees by size class on forest land, North Dakota, 2005 and 2010. Error bars show a 68 percent confidence interval.

Green ash was by far the most numerous species found on forest land in the State with more than 85 million trees in 2010 (Fig. 13). Quaking aspen, bur oak, and Rocky Mountain juniper round out the top four species found on forest land across the North Dakota.

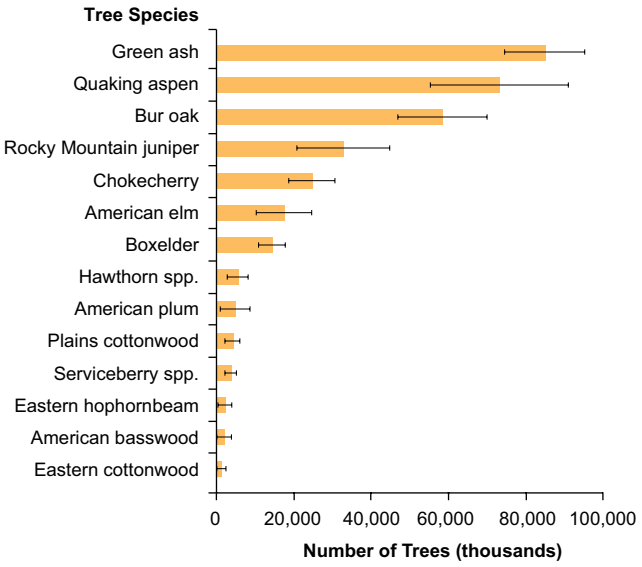


Figure 13.—Most abundant tree species (thousands) of live trees on forest land, North Dakota, 2006-2010. Error bars show a 68 percent confidence interval around the mean.

Although the number of trees remained nearly the same between 2005 and 2010, the species composition across forest land did change by size-class (Table 1).

What this means

Although the number of live trees remained nearly the same between inventories, the species composition did not. For example, decreases in aspen and balsam poplar suggest overmature aspen stands. Lack of disturbance, such as fire or harvesting, has resulted in older stands with little natural regeneration. Many of the stands are characterized by extensive stem decay caused by *Phellinus tremulae* and by *Hypoxylon* canker (*Hypoxylon mammatum*).

Overmaturity and limited natural regeneration threaten the future sustainability of North Dakota's forests. Natural regeneration is hindered by the lack of processes that promote regeneration (flooding, prescribed fire, and harvesting). Limited species diversity is an underlying threat to the long-term sustainability of the State's forest resources. The climate and soils of the northern plains limits the number of tree species that can survive. Forests composed of one or few species often have experience 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).

Table 1.—Tree species by size class with the largest increase/decrease in the number of trees and percent change between the 2005 and 2010 inventories.

Population Change	Species	Percent Change	2005 Thousands of Trees	2010 Thousands of Trees
	Sawtimber			
Increase				
	Rocky Mountain juniper	38.1	2,853.0	3,942.5
	American basswood	30.1	429.5	558.9
	Siberian elm	22.6	144.1	176.7
	Boxelder	21.9	1,484.2	1,810.3
	Bur oak	12.6	3,088.3	3,478.7
	Cottonwood spp.	6.2	2,245.2	2,385.6
Decrease				
	Eastern redcedar	-60.2	77.0	30.7
	Quaking aspen	-40.4	2,953.1	1,543.6
	Balsam poplar	-18.9	75.7	61.3
	American elm	-3.1	562.2	544.4
	Green ash	-2.2	3,242.4	3,169.5
	Poletimber			
Increase				
	Rocky Mountain juniper	35.2	4,974.3	6,728.8
	Siberian elm	16.3	321.6	374.3
	Green ash	8.9	21,355.4	23,264.3
	American basswood	6.9	446.3	477.1
	American elm	6.7	4,087.5	4,363.4
	Bur oak	5.1	22,134.0	23,275.0
Decrease				
	Eastern redcedar	-56.4	152.4	66.4
	Balsam poplar	-40.9	1,602.2	946.8
	Quaking aspen	-13.3	13,536.6	11,726.4
	Cottonwood spp.	-12.9	2,343.5	2,039.2
	Sapling			
Increase				
	Cottonwood spp.	222.0	445.3	1,434.1
	Green ash	16.3	50,419.7	58,660.1
	Rocky Mountain juniper	10.7	19,994.7	22,390.9
Decrease				
	Balsam poplar	-82.6	2,196.2	382.0
	Siberian elm	-53.3	1,769.5	825.7
	American basswood	-33.6	1,726.9	1,146.0
	Quaking aspen	-15.4	70,976.8	60,011.1
	Boxelder	-6.5	8,170.9	7,634.0
	Bur oak	-2.9	32,794.5	31,842.3

Forest Biomass

Background

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

What we found

Live aboveground tree biomass is estimated at 18.3 million dry tons, an average of about 24 dry tons/acre of forest area (Figs. 14, 15). Total aboveground tree biomass on forest land increased by 0.8 million dry tons (<1 percent) between 2005 and 2010. The bole (main stem) of trees accounts for 63 percent (roughly 6 out of every 10 dry tons) of aboveground tree biomass in the State (Fig. 16). Stumps, tops, and limbs account for 24 percent of aboveground biomass and small trees (1 to 5 inches d.b.h.) account for the remaining 10 percent. More than 76 percent of the state total for aboveground biomass (trees) was found on privately owned forest lands. Only county owned and local government owned forest lands had a higher per acre tonnage of biomass than privately held forest lands (Fig.17).

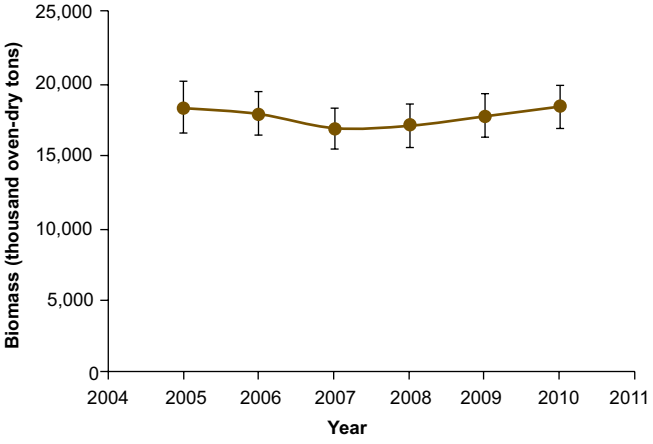


Figure 14.—Live-tree and sapling biomass (dry short tons) on forest land, North Dakota, 2010. Error bars show a 68 percent confidence interval around the mean.

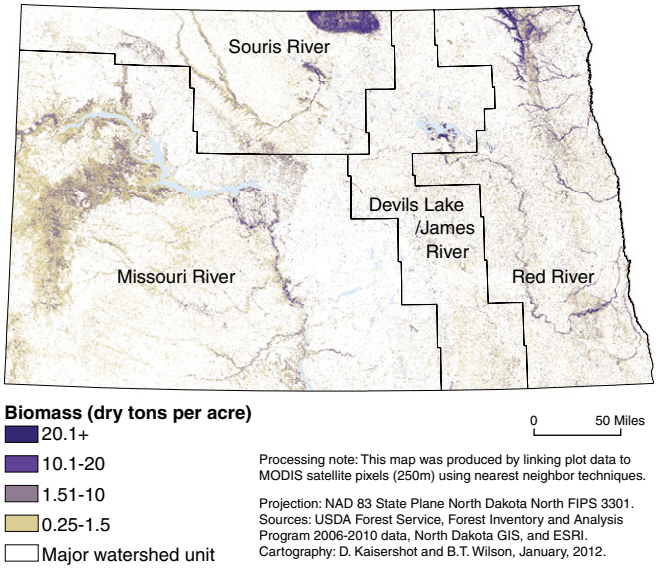


Figure 15.—Live-tree biomass (dry tons per acre) on forest land, North Dakota 2010.

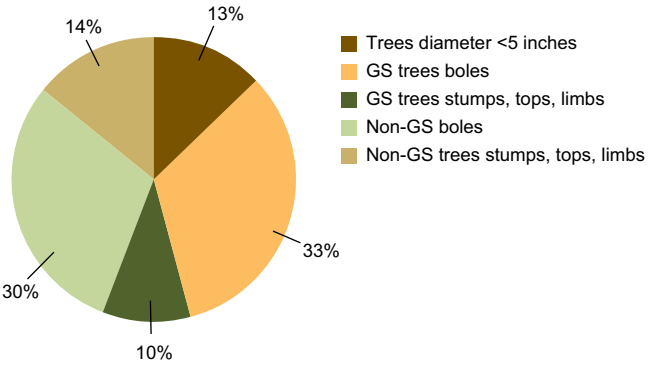


Figure 16.—Forest biomass on forest land by tree component, North Dakota, 2006-2010. (Note: GS refers to growing-stock trees while non-GS refers to nongrowing-stock trees greater than 5.0 inches in diameter).

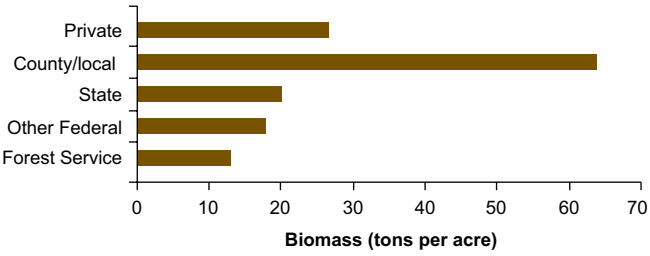


Figure 17.—Ownership of forest biomass (short dry tons per acre) for growing-stock and nongrowing-stock trees on forest land, North Dakota, 2010.

What this means

North Dakota is slowly but steadily gaining tree biomass as the forests continue to grow and mature. Because tree boles on forest land contain the most tree biomass, the management of private forest land strongly influences the future of not only the biomass resource but also the carbon sequestration and future wood availability.

Forest Carbon

Background

Collectively, forest ecosystems represent the largest terrestrial carbon sink on earth. The accumulation of carbon in forests through sequestration helps to mitigate emissions of carbon dioxide to the atmosphere from sources such as forest fires and burning of fossil fuels. The FIA program does not directly measure forest carbon stocks in North Dakota. Instead, a combination of empirically derived carbon estimates (e.g., standing live trees) and models (e.g., carbon in soil organic matter as a function of stand age and forest type) are used to estimate North Dakota's forest carbon. Estimation procedures are detailed by Smith et al. (2006).

What we found

North Dakota's forests contain more than 44 million tons of carbon. Soil organic matter (SOM) represents the largest forest ecosystem carbon stock in the State at more than 26 million tons, followed by live trees at almost 11 million tons (Fig. 18). Within the live-tree pool, merchantable boles contain the bulk of the carbon (~ 5.8 million tons) followed by roots (~ 1.8 million tons) and tops and limbs (~ 1.6 million tons). Most of North Dakota's forest carbon stocks are found in moderately aged stands 41 to100 years old (Fig. 19). Early in stand development most forest ecosystem carbon is in the SOM and belowground tree components. As forest stands mature, the ratio of aboveground to belowground carbon slowly shifts, and after 100+ years ecosystem carbon is evenly split between aboveground and belowground components. This trend continues well into stand development as carbon accumulates in live and dead aboveground components. Forest carbon stocks per acre vary substantially by forest type in North Dakota (Fig. 20). Nonstocked forestland had the least amount of forest carbon per acre (~ 25 tons) while exotic hardwoods had the most (~81 tons). Soil organic matter is the dominant carbon pool in all forest types, but the distribution of forest carbon in the other pools is quite variable. In the exotic hardwoods group, for example, 49 percent (~ 39 tons) of the forest carbon is in live and dead biomass, whereas in the other hardwoods group, only 10 percent (~ 4 tons) is in live and dead biomass.

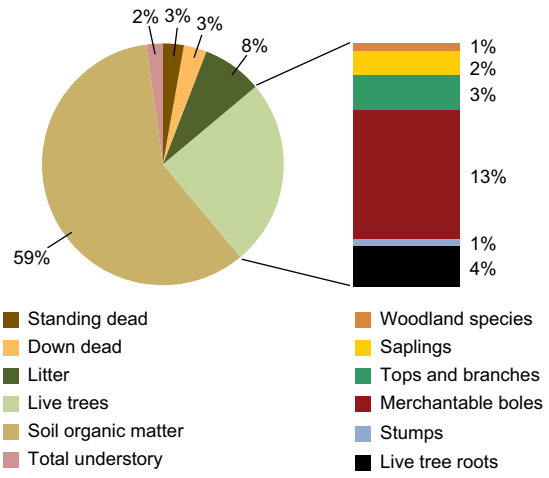


Figure 18.—Total forest carbon stocks, North Dakota 2010.

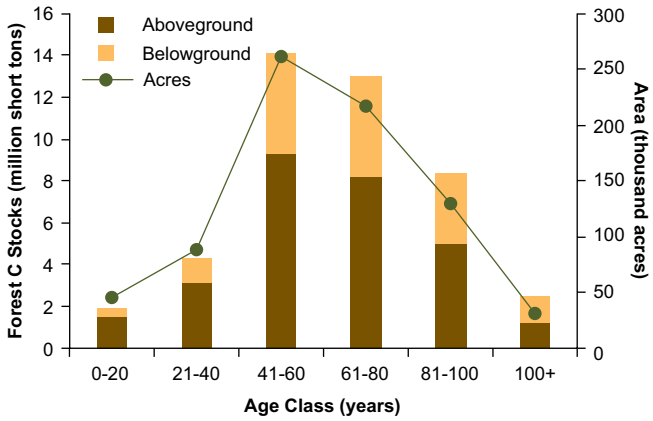


Figure 19.—Forest carbon stocks by stand-age class, North Dakota, 2010.

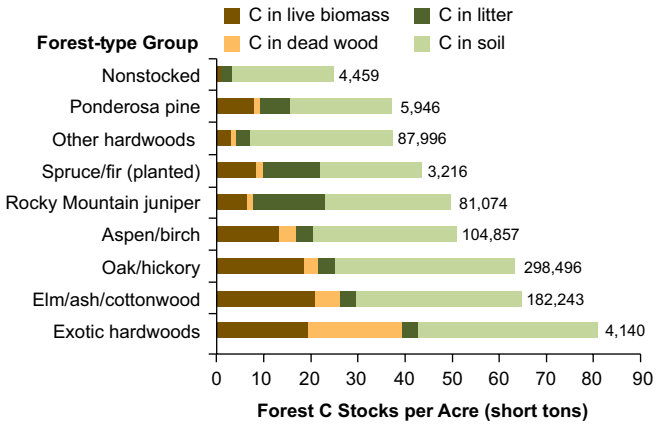


Figure 20.—Forest carbon stocks per acre, by forest type, North Dakota, 2010.

What this means

Carbon stocks in North Dakota's forests have increased substantially over the last several decades. Most of the forest carbon in the State is found in moderately aged stands dominated by relatively long-lived species. This suggests that North Dakota's forest carbon will continue to increase as stands mature and accumulate carbon in aboveground and belowground components. Given the age-class structure and species composition of forests in North Dakota, there are many opportunities to increase forest carbon stocks. That said, managing for carbon in combination with other land management objectives will require careful planning and creative silviculture beyond simply managing to maximize growth and yield.

Stand Age

Background

Stand age is estimated by counting growth rings on tree cores sampled from dominant or codominant trees in the overstory of forest stands. Estimating age is an important tool that provides information about the successional development of North Dakota's forest lands.

What we found

North Dakota's forests can be categorized into six broad stand-age classes: 0 to 20, 21 to 40, 41 to 60, 61 to 80, 81 to 100, and 100+ years (Fig. 21). Close to half of the forest stands in North Dakota are in the 61 years of age or older stand age classes. Stand age varies by forest types. Ponderosa pine, bur oak, Rocky Mountain juniper, and elm/ash forest types have 60 percent or more of forests stand acreage in the 61+ stand age classes. The elm/ash and cottonwood forest types have more than 40 percent of stand acreage classified in the 61+ stand age classes. The aspen forest type has over 63 percent of stand acreage estimated at 41+ stand age classes. Forest-type groups dominated by Rocky Mountain juniper, bur oak, and cottonwood contain a greater proportion of forest land area in the oldest stand age classes (Fig. 22).

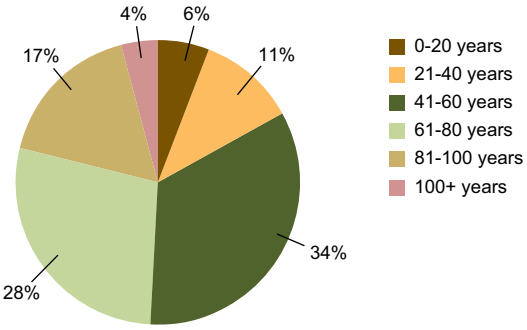


Figure 21.—Distribution of forest land by stand-age class, North Dakota, 2010.

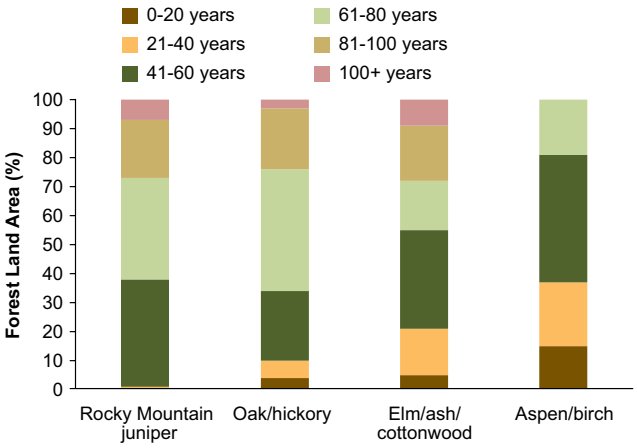


Figure 22.—Distribution of proportion of forest land area for select forest-type groups by stand-age class, North Dakota, 2010

What this means

More than 82 percent of the forest stands in North Dakota are 41 years of age or older. Nearly half (49 percent) of the forest stands in the State are 61 years of age or older. Lack of regeneration is an issue of concern for many forest types within the State, due in part to the lack of disturbances that are required to create suitable seedbeds and promote root suckering.

Growing-Stock Volume

Background

Growing-stock volume is the amount of sound wood in live, commercial tree species. In addition, trees must be at least 5 inches in d.b.h. or greater and free of defect. This measure has traditionally been used to ascertain 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 North Dakota's timberland is estimated at 341.2 million cubic feet (Fig. 23). Five species account for 93 percent of all growing-stock volume in North Dakota: cottonwood, bur oak, green ash, aspen, and American elm (Fig. 24). Of the top five species in 2010, cottonwood is the only species to increase in growing-stock volume. Growing-stock volume currently averages 639 cubic feet per acre of timberland, down by about 7 percent from the 2005 inventory (Fig. 25).

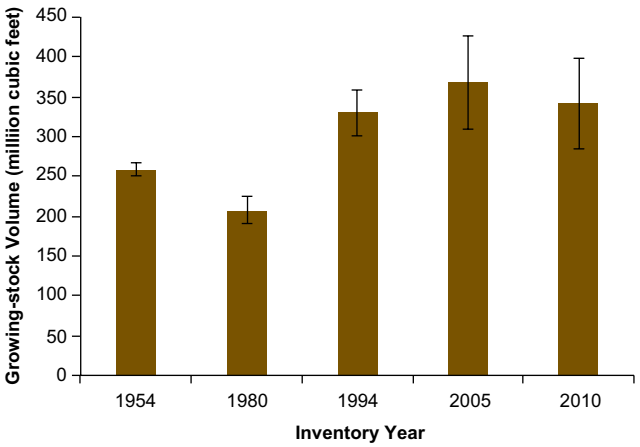


Figure 23.—Total growing-stock volume on timberland, North Dakota, 1954-2010. Error bars show a 68 percent confidence interval around the mean.

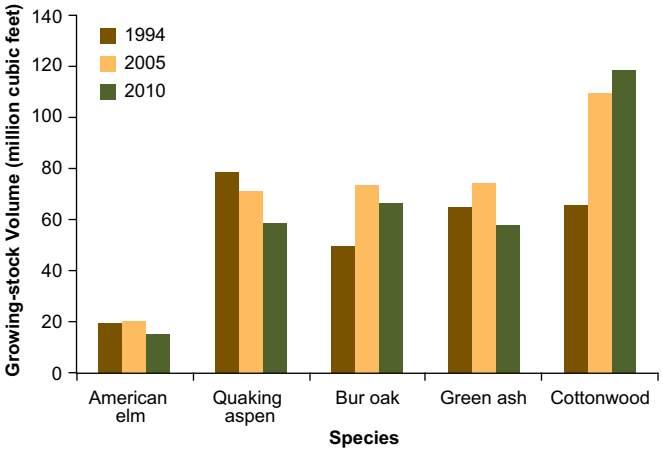


Figure 24.—Total growing-stock volume on timberland by select species, North Dakota, 1994-2010.

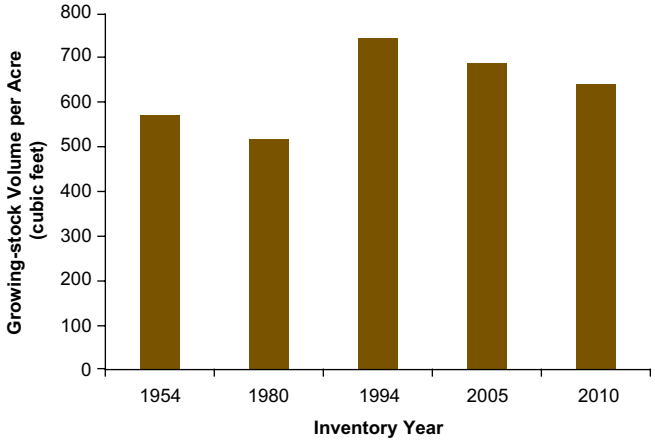


Figure 25.—Average growing-stock volume per acre of timberland in North Dakota, 1954-2010.

What this means

The decrease in growing-stock volume is due in part to the age structure of many forest stands, along with harsh climatic factors including limited rainfall and drying winds that limit tree growth. The lack of natural disturbance such as fire and flooding or human disturbance such as harvesting may also play a role.

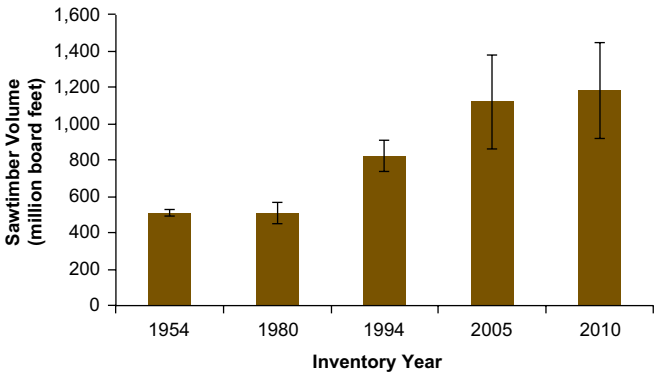


Figure 26.—Total sawtimber volume on North Dakota's timberland, 1954-2010. Error bars show a 68 percent confidence interval.

Sawtimber Volume

Background

Sawtimber trees are live trees of commercial species that contain either one 12-foot or two noncontiguous 8-foot logs that are free of defect. Hardwoods must be at least 11 inches d.b.h. and softwoods must be 9 inches d.b.h. to qualify as sawtimber. Sawtimber volume is defined as the net volume of the saw log portion of live sawtimber, measured in board feet, from a 1-foot stump to minimum top diameter (9 inches for hardwoods and 7 inches for softwoods). Estimates of sawtimber volume, expressed as board feet (International ¼-inch rule), are used to determine the monetary value of wood volume and to identify the merchantable wood availability.

What we found

Sawtimber volume is estimated at 1.183 billion board feet on North Dakota's timberlands, an increase of 5 percent between 2005 and 2010 (Fig. 26). Average sawtimber volume per acre is 2,216 board feet, an increase of 114 board feet since 2005. Four species—cottonwood, bur oak, green ash, and aspen—account for 88 percent of the sawtimber volume on timberland in the State (Fig. 27). Even though the top four species account for the majority of sawtimber volume, green ash and aspen actually decreased in total sawtimber volume on timber land between 2005 and 2010 (Fig. 28).

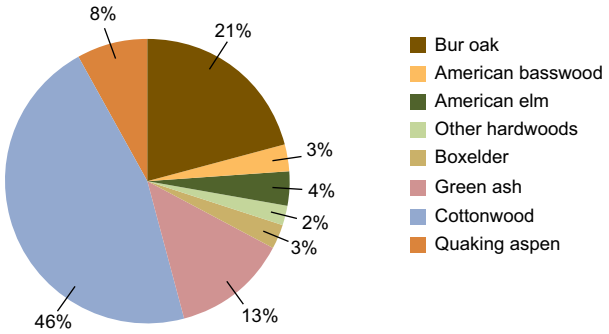


Figure 27.—Percentage of total sawtimber volume by species/species group on timberland in North Dakota, 2010.

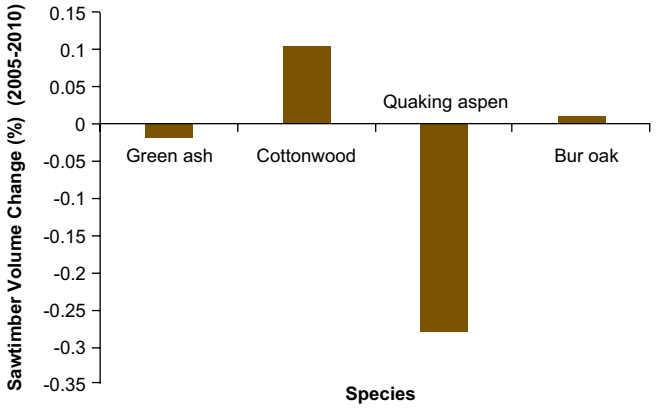


Figure 28.—Percent change in sawtimber volume, four most abundant species, between inventory periods, North Dakota, 2005-2010.

What this means

Sawtimber volume continues to increase at a slow but steady pace as the State's forests mature. Cottonwood volume accounts for nearly half of all the State's sawtimber volume. As forests continue to age, we could see a decrease in total sawtimber volume in the future. Based on harvest removals, sawtimber volume on timberland should be able to supply the forest product industry in the State.

Stocking and Stand-size Class

Background

Stocking provides information on the degree of occupancy of land by trees compared with a desired level for balanced health and growth. Stocking levels are calculated using a combination of number of trees, species, sizes, and spacing. A fully stocked stand indicates full utilization of the site. In stands of trees more than 5 inches in diameter, 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 more than 5 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 (see page 12 for definitions). 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

Just over 14 percent of the timberland in North Dakota is fully stocked or overstocked, 28 percent is moderately stocked, and 68 percent is poorly stocked or nonstocked. The proportion of large-diameter stands that are overstocked or fully stocked is 7 percent, followed by seedling-sapling stands (5 percent) and medium-diameter stands (2 percent). Stocking levels vary by forest type (Fig. 29). The aspen forest type is 76 percent moderately or fully stocked, while the elm/ash type is only 18 percent moderately or fully stocked.

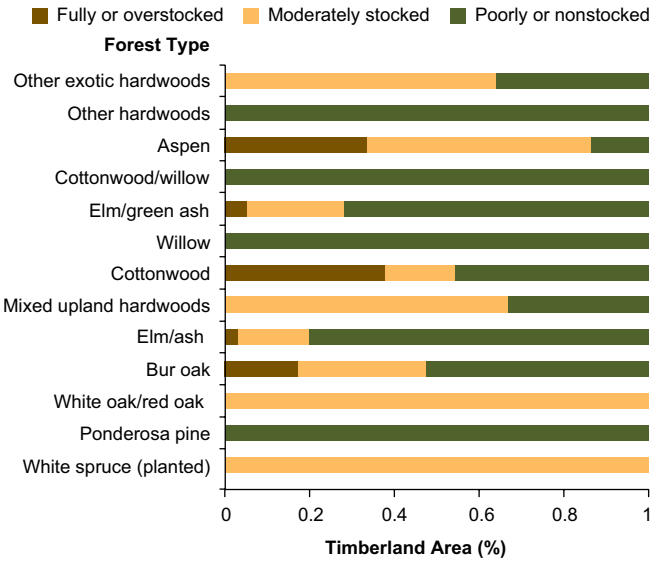


Figure 29.—Proportion of timberland area by stocking class for each forest type, North Dakota, 2010.

The forests of North Dakota are fairly evenly divided between medium and large stand-size classes. Large-diameter stands (where a plurality of stocking is in hardwoods with a d.b.h. > 11 inches and softwoods with a d.b.h. > 9 inches) are found on 35 percent of North Dakota's timber land. Medium-diameter stands, where a plurality of stocking is in softwood trees from 5 to 9 inches and hardwood trees from 5 to 11 inches, occupy 39 percent of the timberland in North Dakota. Seedling-sapling stands, where a plurality of stocking is in trees less than 5 inches d.b.h., occupy 25 percent of the timberland in the State. The proportion of land area in each of the stand-size classes varies considerably by forest type (Fig. 30). More than 62 percent of the bur oak forest type is in the medium-diameter stand-size class. The willow forest type has more than 68 percent stocking in the small-diameter class, while the cottonwood type has 88 percent in the large-diameter stand-size class.

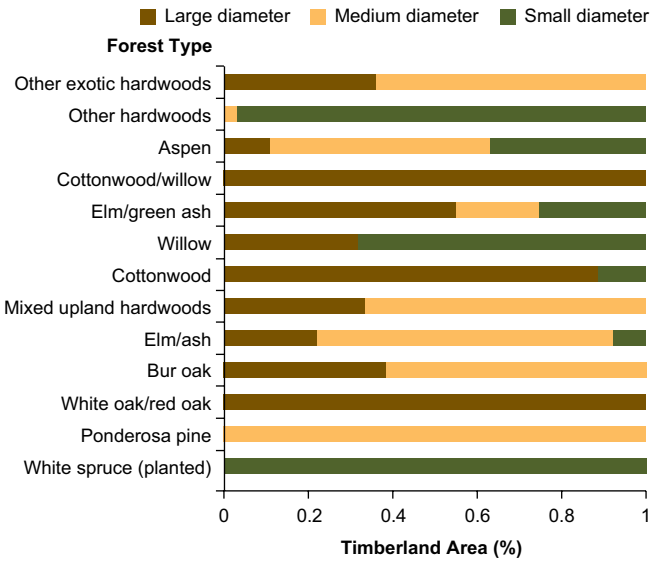


Figure 30.—Proportion of timberland area by stand-size class for each forest type, North Dakota, 2010.

Forty-five percent of timberland acreage in North Dakota has a basal area of more than 80 square feet per acre, 31 percent of timberland acreage has a basal area of more than 40 percent (Fig. 31).

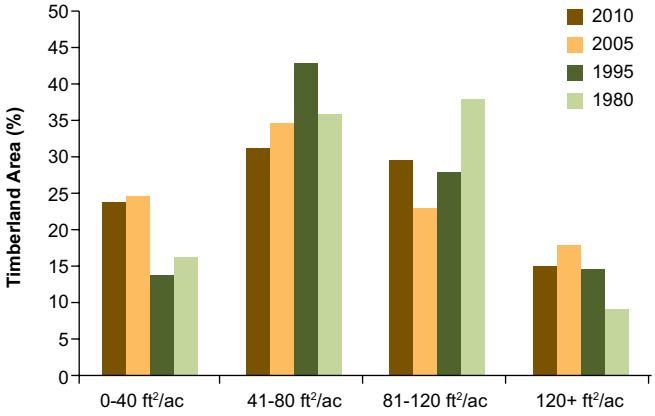


Figure 31.—Proportion of timberland by all live basal area, North Dakota, 2010, 2005, 1995, 1980.

What this means

The density and size of stands across North Dakota provide information on the stages of stand development and forest stocking levels. Determining stages of stand development helps assess the future growth and mortality of the State's forest resources and help guide future forest management objectives. Case in point, the high proportion of large-diameter cottonwood stands points to problems with cottonwood regeneration. Poor cottonwood regeneration can be tied to the shifts in natural disturbance regimes required to perpetuate cottonwood forests. Flood control structures on many of the major rivers across the State have resulted in the loss of suitable sites for cottonwood regeneration. For cottonwood to remain a viable forest type in North Dakota, active management to promote cottonwood regeneration will be necessary.

Tree Growth

Background

A stand's capacity for growth (i.e., for trees to increase in volume) is an indication of the overall condition of the forest and more specifically of tree vigor, forest health, and successional stage. Forest growth is measured as average annual net growth, where net growth is equal to gross growth minus mortality. Average annual net growth represents an average for the annual change in volume between the two most recent inventories, 2001 to 2005 and 2006 to 2010, for this report.

What we found

The average annual net growth of live trees on forest land from 2005 to 2010 was 13.5 million cubic feet or roughly 1.9 percent of the total live-tree volume in 2010. Growth expressed as a percent of volume is presented for the 12 most abundant species (by cubic foot volume) in North Dakota in 2010 (Fig. 32). The growth rate for ponderosa pine was the greatest at 19.7 percent. The growth rate for quaking aspen was barely positive at 0.1 percent due to excessive mortality rates. The average annual net growth rate of live trees on forest land as a percent of volume varies by landowner group. The rate is highest for State and local government (3.2 percent) followed by national grassland (2.3 percent), private (2.1 percent), and finally other Federal (-2.1 percent).

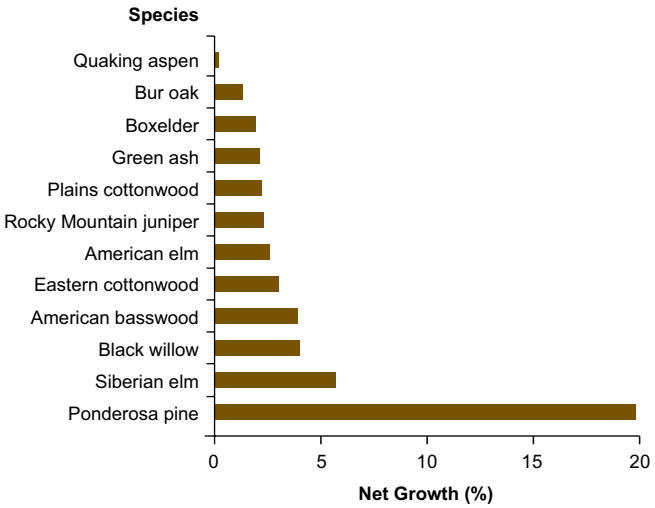


Figure 32.—Average annual net growth of live trees on forest land as a percent volume for 12 most abundant species by volume in North Dakota, 2010.

What this means

Growth rates are useful indicators of sustainability, disturbance trends, species vitality, and direction of succession. But growth 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 more than 5 inches in diameter. As a result, information on the understory component is not reflected in any of these measures.

Tree Mortality

Background

Forest health, vigor, and rate of accretion and depletion are all influenced by tree mortality. Mortality can be caused by insects, disease, adverse weather, succession, competition, fire, senescence, human/animal activity, or a combination of all these factors. Tree volume lost as a result of land clearing or harvesting is not included in mortality estimates. Growing-stock mortality estimates represent the average cubic foot volume of sound wood in growing-stock trees that died each year as an average for the years between inventories, 2001 to 2005 and 2006 to 2010.

What we found

The average annual live-tree mortality on forest land for North Dakota is 13.1 million cubic feet or roughly 1.8 percent of the 2010 live-tree volume. Mortality expressed as a percent of volume is presented for the 11 most abundant (by cubic foot volume) species in North Dakota in 2010 (Fig. 33). The mortality rate for balsam poplar is the highest at 15.1 percent; the mortality rate for eastern cottonwood is the lowest at 0.1 percent.

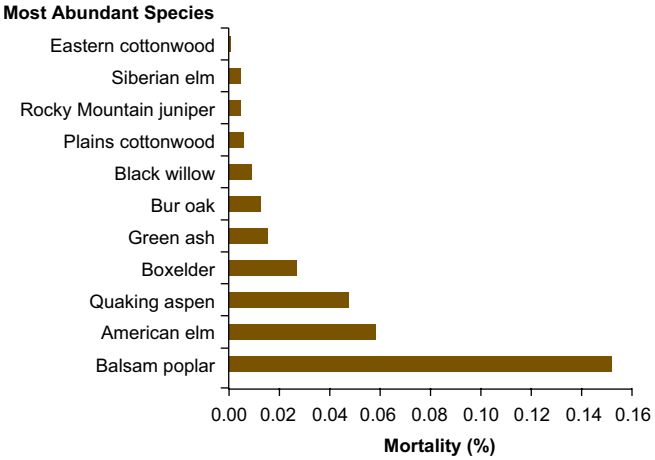


Figure 33.—Average annual live-tree mortality on forest land as a percent volume for 11 most abundant species in North Dakota, 2010.

The primary cause of mortality could not be determined in 31 percent of the cases, which is not surprising considering that the trees are revisited only every 5 years so a tree could have been dead for up to 5 years when revisited by the field crews. Among the various identifiable primary causes of tree mortality were disease (27 percent), animal (21 percent), weather (17 percent), fire (3 percent), and other vegetation (<1 percent).

The mortality rate of live trees on forest land as a percent of current live-tree volume varies by landowner group. The rate is highest for other Federal (5.1 percent) followed by private land owners (1.8 percent), national grassland (0.5 percent), and State and local governments (0.2 percent).

What this means

Tree diseases such as Dutch elm disease and *Hypoxylon* canker, animal interaction (deer browse and grazing), and weather events were the most identifiable cause of tree mortality in North Dakota forests. Other factors, such as the increasing age of North Dakota's forests and the natural mortality patterns during stand development/succession, also play a role in tree mortality. Balsam poplar, American elm, and aspen tree species seem to have a higher rate of mortality than other species in the State. Forest pests, such as defoliating insects (forest tent caterpillar), wood rotting fungi and canker diseases (*Phellinus tremulae* and *Hypoxylon* canker) contribute to the deterioration of aspen and balsam poplar stands across the State. The American elm once was a major component of the State's riparian forests and occupied a wide range of sites. However, Dutch elm disease spread aggressively and decimated the elm population that once made up a large portion of the North Dakota's riparian forests.

Tree Removals

Background

There are three types of removals: harvest removals, mortality removals (i.e., trees killed during the harvesting process or left on the land), and diversion removals (i.e., living trees previously on land classified as forest land but now on land classified as nonforest land).

What we found

The average annual live-tree removals on forest land for North Dakota is 3 million cubic feet or roughly 0.4 percent of the total tree volume in 2010. Removals expressed as a percent of volume was examined for six select species in North Dakota in 2010 (Fig. 34). The removals rate for eastern redcedar is the highest at 3.10 percent, while the removals rate for quaking aspen is the lowest at 0.05 percent. The removals rate as a percent of volume varied by landowner group. The rate is highest for State and local governments (0.24 percent) followed by private land owners (0.18 percent), and other Federal and national forest (0.00 percent).

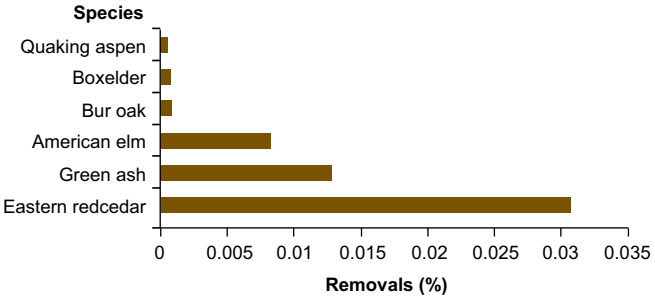


Figure 34.—Average annual removals of live trees on forest land as a percent of volume for six species in North Dakota, 2010.

Roughly 66 percent of the removals of live trees from forest land in North Dakota, as measured from FIA field plots, is due to land use change where trees were left standing but the land they were on was reclassified by FIA from forest land to nonforest land. The rest of removals are due to harvesting activities.

What this means

Removal rates are indicative of both land use change and harvest in North Dakota forests. Landowner objectives can have a large impact on removal rates. On average, in North Dakota, State and county lands are more actively managed than other ownerships. Harvest removals rates are highest on State and local government lands.

Standing Dead Trees

Background

At first glance, a standing dead tree may be viewed as an eyesore or a good piece of wood to burn or add to the landfill. To wildlife, standing dead trees are a source of food in the form of the many insect species attracted underneath bark, and a home in the form of a nesting cavity. More than 40 species of wildlife use dead and dying trees to build their nests in North Dakota (USGS 2006).

Standing dead trees that are large enough to meet habitat requirements for wildlife are referred to as snags. Standing dead trees are important indicators of wildlife habitat and past mortality events and they provide carbon storage. The number and density of standing dead trees, together with decay classes, species, and sizes, define an important wildlife habitat feature across North Dakota's forests.

What we found

More than 75 percent of the estimated 12 million standing dead trees are present in the oak, elm/ash/cottonwood, and aspen/birch forest-type groups. Among the most common standing dead tree species are quaking aspen, American elm, green ash, Rocky Mountain juniper, and bur oak. Quaking aspen make up 27 percent of all standing dead trees (Fig. 35). Most standing dead trees are between 5 and 6.9 inches d.b.h. (Fig. 36). That is, the numbers of smaller diameter standing dead trees substantially exceed those of larger diameter trees. Compared to larger dead trees, standing dead trees of smaller diameter tend to have less advanced decay; a decay class of 2 was most prevalent across standing dead trees of all sizes except the largest diameter class.

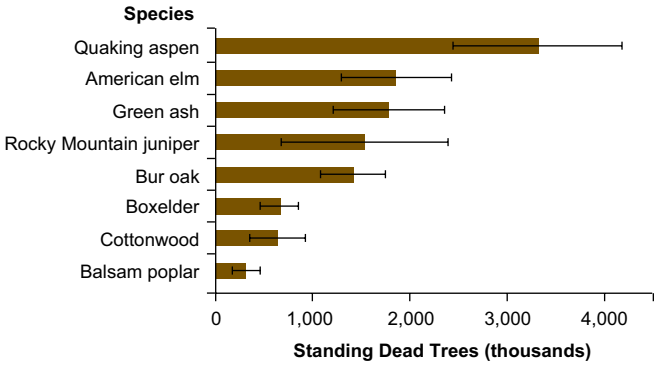


Figure 35.—Number of standing dead trees for the eight most common standing dead trees species, North Dakota, 2010. Error bars show a 68 percent confidence interval around the mean.

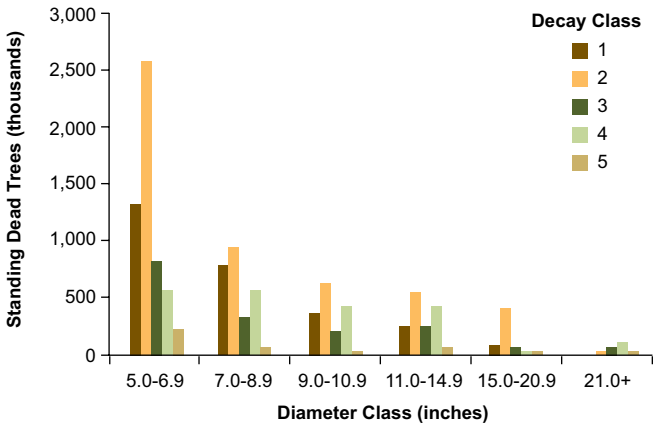


Figure 36.—Distribution of standing dead trees by decay and diameter classes for all standing dead trees in North Dakota, 2010 (decay class 1= least decayed, decayed class 5 = most decayed).

What this means

Among possible reasons for standing dead trees in North Dakota forests are diseases and insects, weather damage, fire, flooding, drought, and competition. The dominance of quaking aspen and American elm snags in particular might be accounted for by diseases such as *Hypoxylon* canker and *Phellinus tremulae* (of fungal origin) and Dutch elm disease. Additionally, normal forest maturation dynamics may be responsible for high mortality rates in the population of these two 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. Once dead, snags provide areas for foraging, nesting, roosting, hunting perches, and cavity excavation for wildlife, from primary colonizers such as insects, bacteria, and fungi to birds, mammals, and reptiles.

Forest Indicators

Old boxelder along the Red River near Hickson, ND. Photo by Robert Harsel, North Dakota Forest Service, used with permission.

Down Woody Materials

Background

Down woody materials, including fallen trees and branches, fill a critical ecological niche in North Dakota's forests. They provide valuable wildlife habitat in the form of coarse woody debris, contribute to forest fire hazards via surface woody fuels, and contribute to carbon stocks in the form of slowly decaying large logs.

What we found

The fuel loadings and subsequent fire hazards of dead and down woody material in North Dakota's forests are relatively low, especially when compared with the nearby states of South Dakota and Minnesota (Fig. 37). The size distribution of coarse woody debris (diameter larger than 3 inches) is overwhelmingly dominated (89 percent) by pieces less than 8 inches in diameter (Fig. 38a). Moderately decayed coarse woody pieces (decay classes 2 and 3) constitute 70 percent of the decay class distribution (Fig. 38b). The carbon stocks of coarse woody debris appear to be minimal irrespective of standing live-tree basal area on North Dakota's forest land except in well-stocked stands (live-tree basal area between 90.1 and 120.0 square feet) where stocks are approximately 5 tons/acre (Fig. 39).

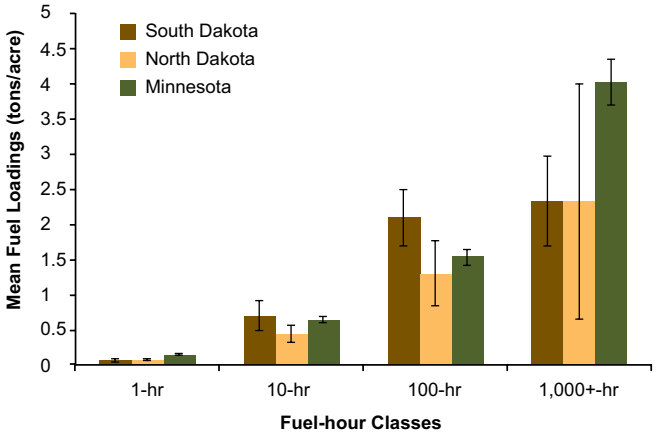


Figure 37.—Estimates of mean fuel loadings by fuel-hour class on forest land for South Dakota, North Dakota, and Minnesota, 2010. Error bars show a 68 percent confidence interval around the mean.

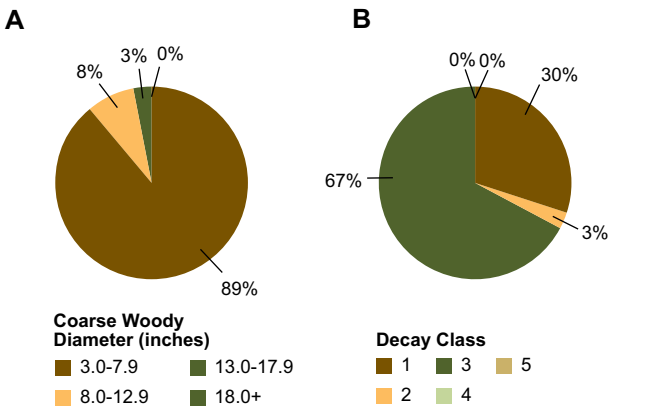


Figure 38.—Mean distribution of coarse woody debris (pieces per acre) by (A) large-end diameter and (B) decay class, North Dakota, 2010.

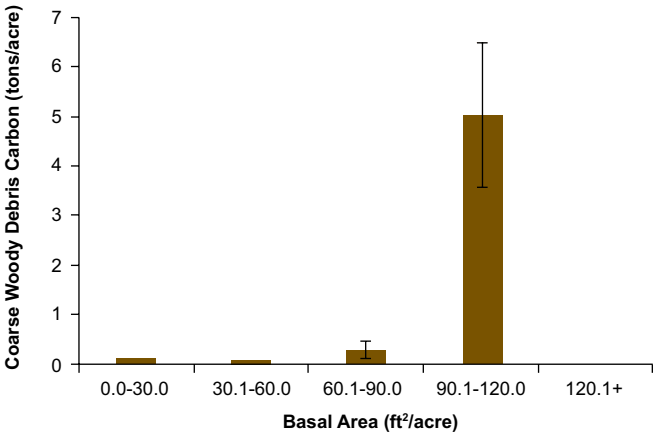


Figure 39.—Estimates of mean coarse woody debris carbon stocks by stand live-tree basal area on forest land, North Dakota, 2010. Error bars show a 68 percent confidence interval around the mean.

What this means

The fuel loadings of down woody material can be considered a forest health hazard only in times of drought or in isolated stands with excessive tree mortality. The ecosystem services (e.g., habitat for fauna or shade for tree regeneration) provided by down woody materials exceed any negative forest health aspects. The population of coarse woody debris across North Dakota consists mostly of small pieces that are moderately decayed. Due to this, coarse woody debris constitutes a small but important carbon stock across North Dakota's forests. Compared to nearby states, the population of down woody materials in North Dakota's forests appears stable while providing valuable ecosystem services.

Vegetation Diversity

Background

The diversity of plant life is an essential foundation in terrestrial forest ecosystems. Because plants are able to convert the sun's energy through photosynthesis, most animals (including humans) are dependent on plants, directly or indirectly, as a source of energy. Some fauna are species-specific and require the presence of a certain species to survive (e.g., various butterflies or moths). Plants can also help filter pollutants, stabilize soil, and increase nitrogen availability. A survey of the plant community can provide information about disturbance, soil moisture, and nutrient availability. In North Dakota, Phase 3 (P3) vegetation data have been collected on approximately 6.25 percent of FIA field plots since 2007, resulting in a complete vegetation survey on four plots. Because North Dakota has a low number of vegetation diversity plots, the results should be interpreted with caution. The data are presented to provide an overview of what was found on the plots but may not represent overall statewide trends.

What we found

North Dakota's forests support many plant species. In 2007-2010, 116 identifiable species were found on P3 plots. Of the 116 species, 45 percent are classified as forb/herbs (Fig. 40), based on USDA's Natural Resources Conservation Service's PLANTS database (NRCS 2011). Shrubs, graminoids (grasses, sedges, rushes), and trees also make up a significant proportion of the total species recorded on P3 plots at 15, 14, and 12 percent, respectively. Of species recorded, 79 percent are native to the United States and 8 percent are introduced (Fig. 41).

On P3 plots in North Dakota, the number of species and genera found range from 30 to 46 per plot with an average of 40. The seven most frequently observed species are listed in Table 2, with western poison ivy being the most common. Two of the most commonly observed species are trees. Of the seven species, one is nonnative (common dandelion). This list also contains the genus "sedge" which may or may not include nonnative sedge species.

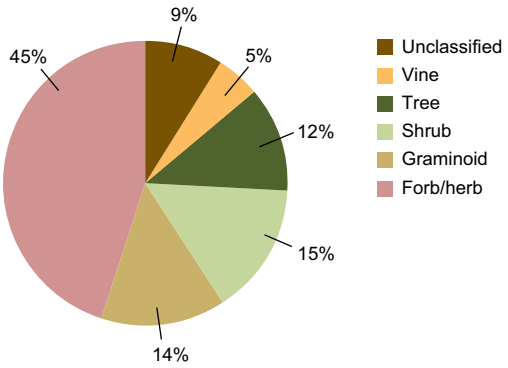


Figure 40.—Percentage of species on North Dakota P3 plots by growth habit category (per PLANTS Database, USDA Natural Resources Conservation Service), 2007-2010.

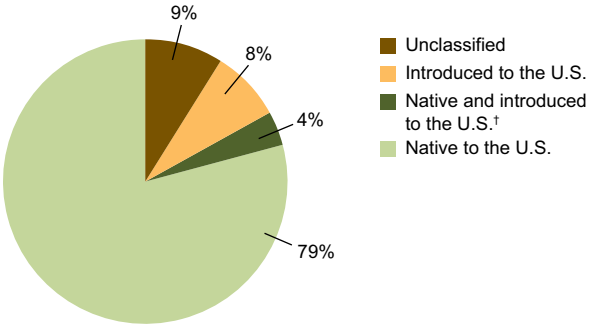


Figure 41.—Percentage of species on North Dakota P3 plots by domestic or foreign origin (per PLANTS Database, Natural Resources Conservation Service), 2007-2010.

† The native and introduced category consists of plant species where some infrataxa are native to the lower 48 states and others are introduced (NRCS 2011).

Table 2.—The seven most abundant plant species or undifferentiated genera found on North Dakota P3 plots, the number of plots they were found on (in parentheses), and the mean number of tree seedlings and saplings per acre on those plots, 2007-2010.

Species	Tree seedlings per acre	Tree saplings per acre
Western poison ivy (4)	5,304	319
Sedge (3)	4,848	325
Northern bedstraw (3)	6,797	300
Common dandelion (3)	5,672	375
Bur oak (3)	6,797	300
Chokecherry (3)	4,848	325
Western snowberry (3)	4,848	325

The presence of nonnative plant species in the forest community is a situation where landowners and managers must be attentive. Differing from invasive plant species, which can be native or nonnative and are discussed in the next section of this report, the list of nonnative plant species contains only species that have been introduced. The most frequently observed nonnative plant species is common dandelion; it was present on three plots (Table 3). Stinging nettle, Kentucky bluegrass, smooth brome, and common yarrow were each found on two plots. Herbaceous plants represented three of the five most commonly observed species and the other two species are graminoids.

Table 3.—The five most commonly occurring nonnative plant species found on North Dakota P3 plots, the number of plots they were found on (in parentheses), and the mean number of tree seedlings and saplings per acre on those plots, 2007-2010.

Species	Tree seedlings per acre	Tree saplings per acre
Common dandelion (3)	5,672	375
Stinging nettle (2)	5,435	225
Kentucky bluegrass (2)	5,435	225
Smooth brome (2)	5,435	225
Common yarrow (2)	8,096	375

What this means

North Dakota's forests support a diverse plant community of 116 identifiable species that comprise five growth habits (forb/herb, graminoid, shrub, tree, and vine). Both native and nonnative species are found on the State's P3 plots. The presence of nonnative and invasive plants within the forest community is problematic because they have the potential to displace the native plants upon which fauna depend. The invasive plants, which are discussed in the next section, are a widespread concern because they have characteristics, such as high seed production and rapid growth, which allow them to quickly spread through the forest understory.

Gathering data on the vegetation communities provides key information on site quality and species distribution. Obtaining future survey data on the presence and abundance of nonnative and invasive plant species will provide knowledge of spread and facilitate management decisions. This will occur via enhancing our understanding of how forest communities change and the factors that influence the presence of various species.

Ozone

Background

Ozone is a naturally occurring component of both the upper and lower atmosphere. Ground-level ozone pollution results largely from industrial processes and automotive engines (U.S. Forest Service 2007). As a result, ozone levels are often higher in and downwind of major industrial and urban centers and in warm temperatures. Elevated concentrations of ground-level ozone can adversely affect forested landscapes, causing direct foliar injury and reduced photosynthetic activity (Coulston et al. 2004). Prolonged exposure to high levels of ozone reduces tree growth, weakens tree defenses (increasing vulnerability to insects and disease), and may lead to changes in forest composition, regeneration, and productivity. Plant response to ozone is monitored using bioindicator plants (biomonitoring) that exhibit increased sensitivity to ambient levels of pollution (Coulston et al. 2003). The use of bioindicator plants provides an indirect measure of air quality, identifying conditions that are favorable for the occurrence of ozone injury.

What we found

When ozone contaminates the environment, the bioindicator plant shows a visible response usually described as upper-leaf-surface ozone stipple for broadleaf plants and chlorotic mottle for pine species. A useful bioindicator plant may be a tree, a woody shrub, or a nonwoody herb species. A variety of bioindicator plants are used in the Plain States on biomonitoring sites to indicate ozone damage (Table 4) with results grouped by year (Table 5). On the eight biomontering sites monitored over the survey period, no ozone injury was detected.

Table 4.—Target species and codes for the Plains States.

Code	Bioindicator Species	Scientific Names
915	Blackberry rubus	*Rubus allegheniensis* (second year canes only)
762	Black cherry	*Prunus serotina*
365	Common and tall milkweed	*Asclepias* spp.
621	Yellow poplar	*Liriodendron tulipifera*
541	White ash	*Fraxinus americana*
931	Sassafras	*Sassafras albidum*
366	Spreading dogbane	*Apocynum androsaemifolium*
364	Big Leaf aster	*Aster macrophyllus: Eurybia macrophylla*
611	Sweetgum	*Liquidambar styraciflua*
761	Pin Cherry	*Prunus pensylvanica*
122	Ponderosa pine	*Pinus ponderosa*
908	Mugwort	*Artemisia douglasiana*
746	Quaking aspen	*Populus tremuloides*
909	Skunk bush	*Rhus trilobata*
905	Ninebark	*Physocarpus malvaceus*
969	Snowberry and coralberry	*Symphoricarpos* spp.
907	Western wormwood	*Artemisia ludoviciana*
968	Evening primrose	*Oenothera elata*

Table 5.—Data collection table for North Dakota, 2010.

Parameter	2006	2007	2008	2009	2010
Number of biosites	8	8	8	8	8
Biosites with injury (%)	0	0	0	0	0
Number of plants evaluated	720	720	881	875	925
Number of plants with injury	0	0	0	0	0
Mean biosite index	0	0	0	0	0

What this means

Based on the survey results, North Dakota's forests are at low risk of suffering ozone damage. For more information on the ozone biomonitoring program, please see U.S. Forest Service 2007.

Focus Issues

Conservation planting around a sugar beet field. Photo by Aaron Bergdahl, North Dakota Forest Service, used with permission.

Great Plains Initiative

Background

North Dakota is approximately 2 percent forest (Smith et al. 2004) and consists mostly of agricultural and grassland vegetation communities. While FIA collects detailed information on trees in areas meeting its definition of forest, resource agencies recognized the lack of available information on the nonforest tree (NFT) resource and how this knowledge gap might hinder wise management of these areas. The U.S. Forest Service periodically conducts assessments of forest health in the Plains States and has identified a number of forest health concerns, including flood damage, ice storms, invasive species encroachment, and various insect and other plant diseases (U.S. Forest Service 2009a, b, c, d). Of particular concern is the spread of the emerald ash borer (EAB) (*Agrilus planipennis* Fairmaire). Since being identified in 2002 near Detroit, MI, EAB has been found in Illinois, Indiana, Iowa, Kentucky, Maryland, Minnesota, Missouri, New York, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and Wisconsin, and as far north as Quebec and Ontario, Canada.

In response to these concerns, state forestry agencies in the Plains States, with funding assistance from the U.S. Forest Service's State & Private Forestry, began a project called the Great Plains Tree and Forest Invasives Initiative (GPI) (Lister et al. 2011). Objectives of the GPI include inventorying the existing NFT resource, identifying EAB mitigation needs and utilization opportunities, and developing 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 provide information that will characterize the NFT resource and supplement the information that FIA collects on the tree resource in forested areas. Data from 299 urban and 150 rural plots were collected in North Dakota during 2008 and 2009.

What we found

One of the goals of the Great Plains Initiative is to assess the ash resource in the Plains States. Ash is the most abundant forest land tree species, with an estimated 85 million ash trees that are 1-inch diameter or greater. GPI findings indicate that ash is also the most abundant tree species in nonforest areas, with an estimate of 34.5 million trees, due in part to its extensive planting (Ball et al. 2007). The species compositions of forest and nonforest areas (with respect to species abundance) are very different (Table 6). Not surprisingly, nonnative, invasive species such as Siberian elm and Russian olive are relatively more abundant in nonforest areas than in forested areas, as are species that are typically planted, such as spruce, and species that grow along stream banks, such as willow.

The GPI inventory also found species composition differences when comparing urban and non-urban areas (Table 7). Spruce emerges as a strong component of urban areas, likely due to ornamental plantings. Several of the species that are relatively abundant in urban areas are not commonly planted, which might seem counterintuitive, but 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. Despite variations in the definition of urban areas, especially with in the context of North Dakota's landscapes, ash is still a strong component in both urban and rural areas.

Of the trees in nonforest areas, 58 million (68 percent) fulfill a windbreak function, with about 60 percent of these windbreak trees being associated with farming or livestock. The remaining windbreak trees are in riparian areas, wildlife plantings, or other natural or semi-natural wooded strips. Species compositions of windbreak and nonwindbreak areas are similar, with some notable exceptions (Fig. 42).

Differences in species composition are likely due to a combination of chance, historical land use, and the effects of natural factors, such as proximity to streams.

Table 6.—Number of trees more than 1 inch in diameter, from the 10 most abundant species, in different land use classes: forest, total nonforest, rural nonforest, and urban nonforest; the nonforest data come from the GPI inventory and the forest land data come from FIA.

Forest land		Nonforest land	
Species	**count**	**Species**	**count**
Green ash	85,094,049	Ash spp.	34,516,728
Quaking aspen	73,281,135	Siberian elm	16,130,741
Bur oak	58,596,104	Cottonwood and poplar spp.	8,733,817
Rocky Mountain juniper	33,062,366	Boxelder	7,738,716
Chokecherry	24,890,859	Willow spp.	4,680,678
American elm	17,707,086	Redcedar / juniper spp.	3,930,421
Boxelder	14,608,995	White oak	3,764,291
Hawthorn spp.	5,728,613	Elm spp.	3,483,274
American plum	5,058,681	Russian olive	916,712
Cottonwood spp.	4,381,704	Spruce spp.	441,076

Rural nonforest land		Urban nonforest	
Species	**count**	**Species**	**count**
Ash spp.	34,111,563	Ash spp.	405,165
Siberian elm	16,074,469	Spruce spp.	140,682
Cottonwood and poplar spp.	8,649,408	Boxelder	90,037
Boxelder	7,648,679	Cottonwood and poplar spp.	84,409
Willow spp.	4,669,423	Elm spp.	67,527
Redcedar / juniper spp.	3,913,539	Apple spp.	56,273
White oak	3,753,036	Siberian elm	56,273
Elm spp.	3,415,747	Maple spp.	28,136
Russian olive	899,830	Ponderosa pine	22,509
Spruce spp.	300,394	Redcedar / juniper spp.	16,882

Table 7.—Total number of trees (and sampling error) by USDA National Agricultural Statistics Service's Cropland Data land use class.

Cropland Data Layer Land Use Class	Number of Trees in Class	% Total Number of Trees	Sampling Error %	% Total Area of Class on Map
Total	**85,011,866**	**100**	**11**	**100**
Idle Cropland, Fallow, CRP	27,055,967	31.8	23	21
Spring Wheat	20,469,435	24.1	28	21
Woodland	10,109,180	11.9	34	2
Grass, Clover, Wild Flowers	8,218,165	9.7	43	11
Wetlands	3,773,386	4.4	67	2
Soybeans	3,771,368	4.4	78	9
Corn, all	2,991,533	3.5	97	3
Sunflowers	2,654,459	3.1	100	2
Urban	1,840,990	2.2	31	4
Alfalfa	1,665,605	2.0	59	1
Pasture, Non-agricultural, Range, Waste, Farmstead	1,618,267	1.9	48	9
Water	628,061	0.7	71	4
Shrubland	167,861	0.2	100	1
Canola	47,589	0.1	100	2
Other	0	0.0	n/a	9

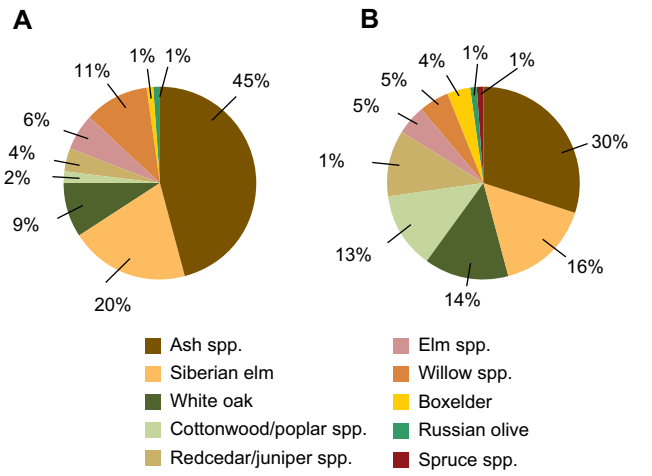


Figure 42.—Percentages of the top 10 tree species by abundance, in windbreak (A) and nonwindbreak (B) areas. Percentages are the percentages of trees in each windbreak category, e.g., ash represents 40 percentof the trees found in windbreaks, 2008 and 2009, North Dakota.

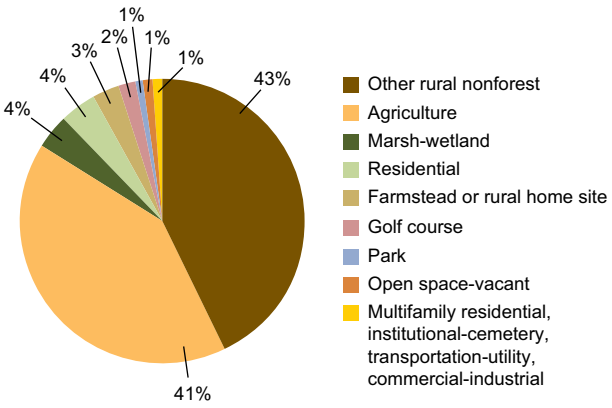


Figure 43.—Different proportions of various nonforest treed land uses. "Other Rural Nonforest" includes idle farmland, windbreaks, shelterbelts, or other similar nonforest areas, 2008 and 2009, North Dakota.

For example, there is a much higher percentage of ash trees in windbreaks, largely because they were planted extensively. Relative amounts of white oak, on the other hand, occur with a higher frequency in non-windbreak areas due to the lower suitability of windbreak sites for this species.

There are almost 720,000 acres of nonforest land with trees greater than 5 inches in diameter in North Dakota divided among several land uses (Fig. 43).

What this means

FIA provides valuable information on various site variables across all lands and information about tree and more detailed site variables on lands meetings its definition of forest. However, until the GPI, little was known about trees in nonforest areas. The GPI data indicate that species composition differs dramatically between forested and nonforested areas of the State, and thus different management approaches should apply. In particular, the ecology of nonforest land with trees is vulnerable to perturbation by outbreaks of the EAB.

Although knowledge of the differences in general is useful, the practical usefulness of the information relates to management of some of the ecosystem services that trees in these areas provide. The information obtained from the GPI can be used to promote wise windbreak stewardship such as monitoring windbreaks for EAB infestation and removing dead or dying trees and replacing them with non-susceptible species. 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, including support for wildlife populations, windbreak functions, energy savings, and forest product industry development.

Emerald Ash Borer Risk

Background

The emerald ash borer is a wood-boring beetle native to Asia (Poland and McCullough 2006). In North America, EAB has been identified only as a pest of ash and at least 16 native species of ash appear to be susceptible (Cappaert et al. 2005, McCullough and Siegert 2007). Trees and branches as small as 1 inch in diameter have been attacked, and while stressed trees may be initially preferred, healthy trees are also susceptible (Cappaert et al. 2005). In areas with a high density of EAB, tree mortality generally occurs 1 to 2 years after infestation for small trees and after 3 to 4 years for large trees (Poland and McCullough 2006). Spread of EAB has

been facilitated by human transportation of infested material. EAB was not found in North Dakota during the 2010 inventory, but the threat of EAB introduction has increased with the discovery of this pest in Minnesota and Iowa.

What we found

North Dakota's forest land contains an estimated 85.9 million ash trees (greater than 1 inch diameter) that account for 131.2 million cubic feet of volume. Ninety-nine percent of the statewide ash resource is composed of green ash, with black ash making up the remaining 1 percent. In addition to being the dominant species of ash in the State, green ash is the most abundant species by number and ranks second in total volume. Ash is distributed across much of North Dakota, but most ash is concentrated in the Turtle Mountain region and in west-central North Dakota (Fig. 44). Ash is present on approximately 542,000 acres, or 70 percent of North Dakota forest land (Fig. 45). Although it generally makes up less than 25 percent of total live-tree basal area (BA), in many areas ash represents more than 50 percent of total basal area.

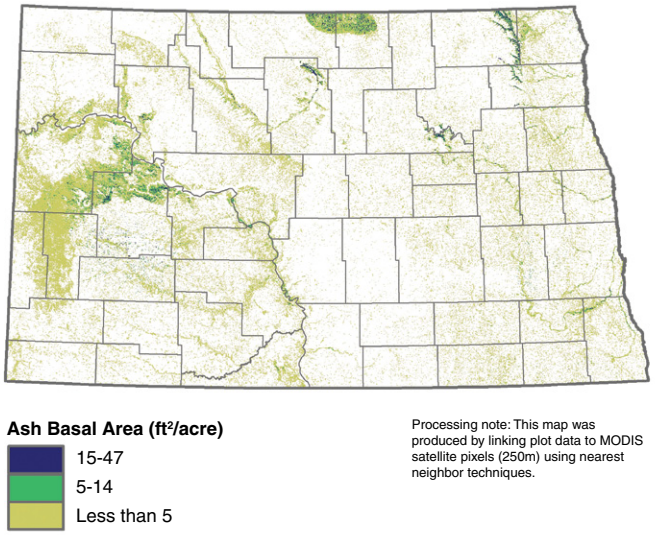


Figure 44.—Ash density on forest land, North Dakota, 2010.

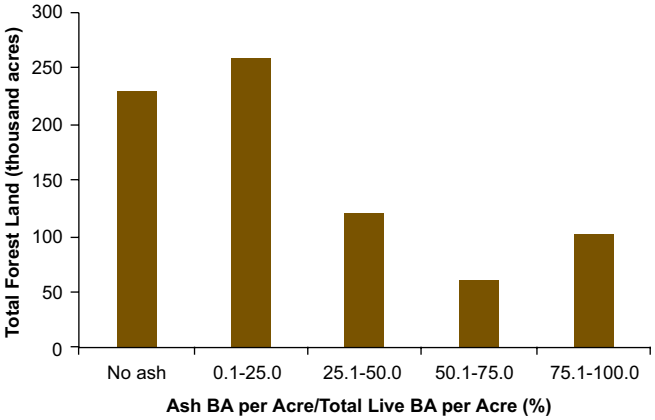


Figure 45.—Presence of ash on forest land, as a percentage of total live-tree basal area (BA), North Dakota, 2010.

What this means

Ash is an important component of North Dakota's forests. EAB has caused extensive decline and mortality of ash throughout the north-central United States and it represents a significant threat to the forested and urban ash tree resource in North Dakota. Continued monitoring of ash resources will help to identify the long-term impacts of EAB in forested settings. Efforts to slow the spread of emerald ash borer will be enhanced by discontinuing the transportation of firewood.

Nonnative and Invasive Plants

Background

Invasive plant species (IPS) supplant native species and change plant communities. They are often very aggressive colonizers that readily establish from vegetative propagules (e.g., multiflora rose) and/or produce copious amounts of seed (e.g., purple loosestrife). After establishment in an area, some IPS can change the soil chemistry by altering nutrient availability (e.g., black locust, common buckthorn), which can displace native species and support their spread. IPS have spread throughout the United States, costing billions of dollars for inspection, monitoring, and eradication (Pimentel et al. 2005). Gathering data on IPS helps individuals and land managers understand the distribution and abundance of these species. In the future, data from

remeasured plots will enhance our understanding of how these species have spread, their impact to the forest community, and factors that influence their presence.

Northern Research Station's FIA (NRS-FIA) program has been monitoring the distribution, spread, and abundance of these species on North Dakota's Phase 2 (P2) invasive plots since 2007. In 2007 through 2010 inventories, invasive species data were collected on 20 forested plots (approximately 20 percent of the P2 field plots). Since North Dakota has only 20 P2 invasive plots, the results should be interpreted with caution. The data are presented to provide an overview of what was found on the plots but may not represent overall statewide trends.

What we found

Data from North Dakota's P2 invasive plots suggest that invasive species are present throughout the State. The list of IPS that the NRS-FIA program monitors is shown in Table 8.

Of the 43 species monitored, seven were present on North Dakota plots. These species are listed in Table 9.

The species recorded on the greatest number of plots was Canada thistle (four plots), followed by bull thistle, leafy spurge, and reed canarygrass (each occurring on two plots). The growth habits of the seven IPS consisted of three herbaceous species, three woody species, and one graminoid. In general, the average cover[2] of the IPS found on the P2 invasive plots was 9.3 percent and ranged from 0.6 percent (bull thistle) to 48.9 percent reed canarygrass. The distributions of the IPS found on P2 invasive plots are shown in Figure 46. The plots with IPS were located in the northeast and west/southwestern part of the State.

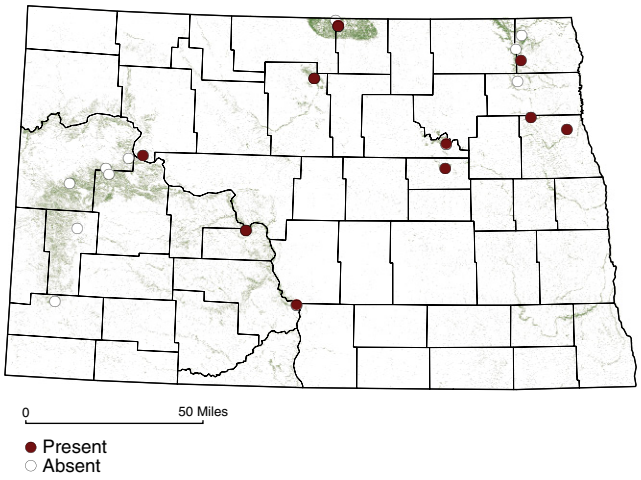
Table 8.—Invasive plant species target list for NRS-FIA P2 invasive plots, 2007 to present.

Tree Species
Black locust *(Robinia pseudoacacia)*
Chinaberry *(Melia azedarach)*
Norway maple *(Acer platanoides)*
Princesstree *(Paulownia tomentosa)*
Punktree *(Melaleuca quinquenervia)*
Russian olive *(Elaeagnus angustifolia)*
Saltcedar *(Tamarix ramosissima)*
Siberian elm *(Ulmus pumila)*
Silktree *(Albizia julibrissin)*
Tallow tree *(Triadica sebifera)*
Tree of heaven *(Ailanthus altissima)*
Woody Species
Amur honeysuckle *(Lonicera maackii)*
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)*
Morrow's honeysuckle *(Lonicera morrowii)*
Multiflora rose *(Rosa multiflora)*
Showy fly honeysuckle *(Lonicera x.bella)*
Tatarian bush honeysuckle *(Lonicera tatarica)*
Vine Species
English ivy *(Hedera helix)*
Japanese honeysuckle *(Lonicera japonica)*
Oriental bittersweet *(Celastrus orbiculatus)*
Herbaceous Species
Black swallow-wort *(Cynanchum louiseae)*
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)*
P. cuspidatum/P. sachalinense hybrid *(Polygonum x.bohemicum)*
Purple loosestrife *(Lythrum salicaria)*
Spotted knapweed *(Centaurea biebersteinii)*
Grass Species
Common reed *(Phragmites australis)*
Nepalese browntop *(Microstegium vimineum)*
Reed canarygrass *(Phalaris arundinacea)*

2 Calculated for each invasive species observed on P2 Invasive plots by summing the average plot coverage for each plot the species occurred on and then dividing by the total number of plots the species occurred.

Table 9.—Identifiable invasive species found on North Dakota P2 invasive plots, the number of plots they were found on (in parentheses), and the mean number of tree seedlings and saplings per acre on those plots, 2007-2010.

Species	Tree seedlings per acre	Tree saplings per acre
Canada thistle (4)	6,180	143
Bull thistle (2)	3,201	173
Leafy spurge (2)	2,099	75
Reed canarygrass (2)	3,201	248
Russian olive (1)	0	0
Common buckthorn (1)	2,741	125
Tatarian honeysuckle (1)	5,098	0



Projection: NAD83, UTM Zone 14
Data Source: USDA Forest Service Forest Inventory and Analysis Program 2007-2010 Phase 2 Invasive and Phase 3 data. State and County layers source: ESRI Data and Maps 2005. Depicted plot locations are approximate.
Cartographer: C. Kurtz.

Figure 46.—Distribution of invasive plant species found on North Dakota FIA P2 invasive plots from 2007 through 2010; approximate plot locations depicted.

What this means

IPS were found on half of the FIA P2 invasive plots in North Dakota. Invasive plants can degrade the quality of the forest through reducing forage, displacing native species, altering nutrient and hydrologic properties, and changing plant communities. Aside from the ecological damage IPS cause, they can also have economic impacts, through lost revenues that would have been derived from the displaced species and through the costs of monitoring, management, and remediation. Monitoring these species in the future will allow managers to observe abundance and spread as well as help determine what site characteristics influence their presence, with the goal of creating forested conditions that minimize invasion and the impact of IPS.

Timber Products

Tongue River near Bathgate, ND. Photo by Robert Harsel, North Dakota Forest Service, used with permission

Timber Products

Background

The harvesting and processing of timber products produces a stream of income shared by timber owners, managers, marketers, loggers, truckers, and processors. In 2007, the wood products and paper manufacturing industries in North Dakota employed more than 2,000 people, with an average annual payroll of $61 million and total value of shipments of $341 million (U.S. Census Bureau 2005). Most of the wood product manufactures in the state are secondary manufactures, such as cabinet and mill works. Sawmills are the primary wood using industry in the State. To better manage the State's forests, it is important to know the species, amounts, and locations of timber being harvested.

What we found

Surveys of North Dakota's wood-processing mills are conducted periodically to estimate the amount of wood volume that is processed into products. This is supplemented with the most recent surveys conducted in surrounding states that processed wood harvested from North Dakota. In 2009, there were 13 active primary wood-processing mills that were surveyed to determine the species that were processed and where the wood material came from. These mills processed 359,300 board feet of saw logs and other wood products.

In 2009, 235,500 cubic feet of industrial roundwood was harvested from North Dakota's forest land. Saw logs accounted for 97 percent of the total industrial roundwood harvested. Cottonwood accounted for almost 88 percent of the total industrial roundwood harvest in 2009 (Fig. 47). Other important species harvested were ponderosa pine, spruce, ash, and bur oak.

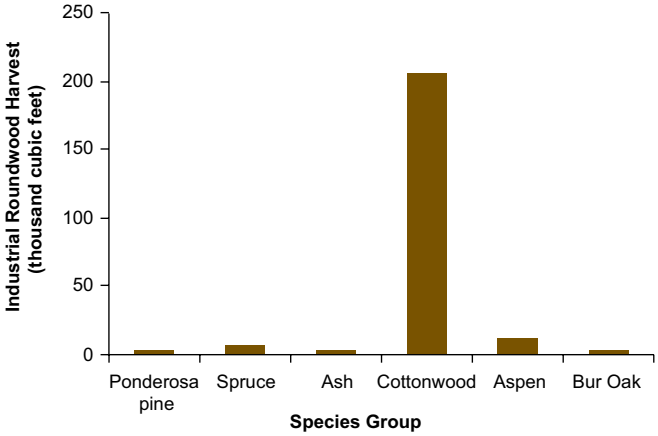


Figure 47.—Industrial roundwood harvested by select species/species group, North Dakota, 2009.

In the process of harvesting industrial roundwood, 79,230 cubic feet of harvest residues were left on the ground (Fig. 48). Sixty-six percent of the harvest residues came from nongrowing-stock sources such as crooked or rotten trees, tops and limbs, and dead trees. The processing of industrial roundwood in the State's primary wood-using mills generated 986,500 green tons of wood and bark residues (Fig. 49). Thirty-nine percent of the mill residues generated were used for domestic fuelwood. Miscellaneous use (25 percent) includes livestock bedding, and small dimension and specialty items. Pulp and composite fiber product mills consumed 8 percent of the mill residues, and mulch consumed 2 percent of the mill residues generated. Twenty-six percent of the mill residues generated by the primary wood processors of North Dakota went unused.

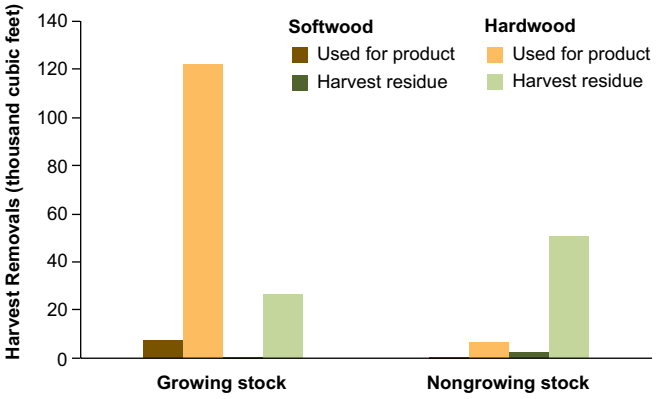


Figure 48.— Distribution of harvest removals for industrial roundwood by source of material, hardwood and softwood, North Dakota, 2009.

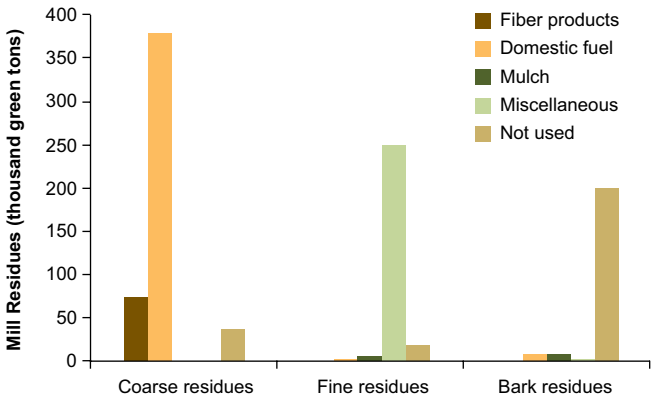


Figure 49.—Distribution of residues generated by primary wood-using mills by method of disposal and type of residue, North Dakota, 2009.

What this means

A comparison of the 2003 and 2009 timber products inventories shows a decrease in industrial roundwood production of 15 percent. This is due in large part to the decrease in industrial roundwood exports to Minnesota mills, even though the total active mills in the State increased from 9 in 2003 to 13 mills in 2010. Cottonwood is still the most commonly harvested species in the State. This is partly due to the fact that elm/ash/cottonwood forest-type group cover's and estimated 182,200 acres of forest land and cottonwoods are some of the State's largest trees. There is also the strong interest from Minnesota's timber industry.

Forest Health Summary

The following summaries provide information on the general conditions of North Dakota's native forests. These narratives depict the factors that have led to the current condition of these resources; they do not necessarily describe specific causal agents of tree/forest decline. The information presented in this section was compiled from various sources and methods including site visits, forest surveys, and personal communication with natural resource professionals.

Elm, Ash, Cottonwood

The elm/ash/cottonwood forest-type group is the most abundant native forest type and is generally found along rivers throughout North Dakota. These forests have changed significantly over the past decades due to damage caused by Dutch elm disease, overgrazing, deer browsing pressure, altered water flows, and conversion to nonforest. Since Dutch elm disease was first detected in 1969, the disease has spread throughout North Dakota. The American elm once was a major component of the State's riparian forests and occupied a wide range of sites. However, Dutch elm disease spread aggressively and decimated the elm population that once made up a large portion of the riparian forests along the Red, James, Sheyenne, and Pembina Rivers. In addition, the disease continues to kill elms that grow in the wooded draws of western North Dakota. Although the American elm has not been entirely eliminated from these forests, the species primarily persists as a small understory tree, occupies a small proportion of the total stand basal area, and often dies before reaching maturity. The loss of American elm dominance in these systems has shifted the species composition toward green ash, boxelder, and other species.

In addition to the impacts of Dutch elm disease, many riparian forests have been converted to nonforest through agricultural and residential development, particularly along the Red River of eastern North Dakota. Other damaging factors include overgrazing and water flow changes that can gradually reduce the vigor of existing trees and destroy understory woody vegetation. Such forest changes and conversions adjacent to watercourses have important implications for water quality, flood control, wildlife habitat and recreation opportunities. With challenges to cottonwood regeneration, which will be discussed next, and the additional threat posed by potential future introduction of the emerald ash borer, the long-term future of riparian forest diversity is unclear.

Cottonwood Forests

The cottonwood forests that occur within the Missouri River flood plain from Garrison Dam to Lake Oahe are in a poor condition due to progressive mortality of mature trees and the absence of natural regeneration to replace those that have died. Before flood mitigation, the Missouri River flood plain was periodically inundated as high spring water flows deposited sand in low-lying areas. These moist sandbars serve as seedbeds for cottonwood and are critical for natural regeneration of the species (Cooper and Van Haverbeke 1990). This historical disturbance regime of periodic flooding drove the succession, distribution, and age-class structure of cottonwood forests along the flood plain (Ball 1997).

In the absence of flooding and subsequent sandbar formation, there is limited cottonwood regeneration to replace the overmature trees that have succumbed to old age. As a result, the flood plain that once persisted as a fluctuating mosaic of backwater wetlands, sandbars, and cottonwood forests now exists as a xeric, fire-prone flood plain bisected by a channelized river. The cottonwood component of the Missouri River flood plain may eventually die out and give way to other tree species (both native and nonnative) with the exception of a few isolated sites adjacent to the ever-deepening river channel.

Aspen Forests

Aspen/birch forests are abundant in the Turtle Mountain region and represent the State's largest concentration of forest land. Quaking aspen is the dominant species in these stands, but paper birch, bur oak, balsam poplar, and green ash can also be common on these sites. A significant portion of the aspen resource can be characterized by low productivity, stem decay, and large stem mortality associated with stand overmaturity. In the absence of stand-replacing disturbances to encourage vigorous aspen regeneration, aspen stands age and deteriorate over time as the result of numerous inciting, predisposing and contributing factors. These may include frost injury, drought, hail damage, windstorms, and damage by several forest pests. Forest pests, such as defoliating insects, wood rotting fungi, and canker diseases contribute to the deterioration of these aspen stands. The Turtle Mountains are prone to periodic defoliation episodes caused by the forest tent caterpillar. Defoliation reduces growth, predisposes trees to other damaging agents, and exacerbates the senescence of aging aspen stands. Internal decay of live aspen trees is common within mature aspen stands, particularly those older than 60 years. Stem decay caused by the fungus *Phellinus tremulae* reduces the amount of usable wood within a stand, in addition to increasing the probability of stem breakage. The wood volume loss due to this stem decay has been increasing as the aspen resource continues to age in the Turtle Mountains. Similarly, mortality of large diameter trees due to *Hypoxylon* canker contributes to the deterioration of older stands.

The damage caused by these pests should not be perceived as unnatural, but rather as a reflection of a disturbance regime shift. Without disturbance (whether by fire, harvesting, bulldozing, or other means) to encourage vigorous aspen regeneration, pests, and environmental factors deteriorate the aging aspen and give way to other species. Throughout its western and eastern range, aspen is a pioneer species that is often succeeded (replaced) by shade-tolerant conifer species in the absence of disturbance. However, many aspen forests of the northern prairie regions of North America convert to shrubland where shade-tolerant conifers do not naturally occur (Harniss 1981, Perala 1990). This successional scenario is apparent within some areas of the Turtle Mountains where beaked hazel dominates the understory of deteriorating aspen stands and prevents the establishment of other tree species.

In addition to the senescence of the aspen resource, many areas in the Turtle Mountains have been converted to pastureland. This conversion may be driven in part by reduced productivity and vigor of the stands coupled with a lack of harvesting opportunities for private landowners. As a result, some private landowners are inclined to clear low-production forests and use the land for agricultural purposes that generate marginal economic benefits.

Fortunately, forest land owners have had a renewed interest in harvesting aspen in recent years. Although clearcutting first may look unappealing, the vigorous regeneration of aspen that soon follows is important for the long-term perpetuation of this unique forest resource. The young aspen stands that regenerate following harvest are beneficial to many wildlife species.

Bur Oak Forests

Bur oak is represented to varying extents in many environments with trees across North Dakota. In some specific areas of North Dakota, namely the Devil's Lake hills and the Sheyenne River valley, oak holds a more predominant position on the landscape. These two oak forests face some of the same forest health challenges, yet some very specific agents affect overall oak health and sustainability.

The water level in Devils Lake has been rising dramatically over the past decades because Devils Lake has no natural outlet. As waters rise, shoreline forests become submerged and die. While the rate of water rise has been quantified, the mortality in lakeside forests has not. Projections indicate that if water levels continue to rise, joining more neighboring bodies of water, 1.6 million trees on 5,800 acres of forest will be destroyed (Devils Lake Chamber of Commerce & Tourism Office N.D.).

Oak savanna-like forests in the Sheyenne River valley also experienced fluxes in water level, however, these have mostly occurred during dormancy. The challenges to oak forest sustainability in these areas are predominantly due to a large deer population inhabiting the area and the invasion of heavy brome grass. These two factors combine for a significant challenge to regeneration as seedlings are not able to become established due to the brome grass–and if they are able to out-compete neighboring vegetation, seedlings are very often heavily browsed and do not reach sapling size.

Ponderosa Pine Forests

Several animals, insect pests, and pathogens are found in the native ponderosa pine stands of southwestern North Dakota. Of these, animal damage caused by deer and porcupines is most apparent. Additionally, shoot death and branch dieback caused by western gall rust, *Diplodia* shoot blight and canker, and pine pitch nodule maker are commonly encountered. Such pests may lead to tree mortality if conditions favor repeated infections/infestations over several years. Many pines weakened by these pests and other factors die following colonization by pine engraver beetles or turpentine beetles. Despite the presence of pests, these isolated pine stands are quite resilient and the level of tree mortality has remained low.

Perhaps the greatest concern in these areas has been wildfire. Years of past fire suppression coupled with high stand density creates conditions that may intensify fire behavior. These wildfire concerns were realized when a large prairie fire spread into portions of the native ponderosa pine stands of Slope County, in September 2004. The fire (known as the Deep Creek Fire) burned through about 800 acres of privately owned forest.

Mortality may reach 100 percent in stands that experienced high fire intensity with severe needle scorching and stem charring, but estimations of tree mortality are uncertain in areas that had less intense fires. The dense stocking and general low vigor of these stands suggest that tree mortality could be significant within the following years. Survey plots were created on these sites to assess delayed tree mortality.

Hazardous Fuel Reduction

The ponderosa pine hazard fuel mitigation site is within a 3,530-acre area representing the northeasternmost extent of ponderosa pine in North America and one of two native pine areas in North Dakota. Adjacent private lands encompass an additional 2,000 to 3,000 acres of ponderosa pine. These lands were targeted due to the U.S. Forest Service prescribed fire program being implemented on lands adjacent to these acres. The project provided risk mitigation by removing hazardous

fuel thus providing a higher degree of protection to communities and homes that may be at risk.

Seasonal sawyers and crew members were assigned to work within the project area. Timber was marked for cutting utilizing a silvicultural prescription outlined with a Forest Stewardship Plan, sawyers cut timber in the marked units, and crews piled the material in strategic locations for burning at a later date. Cutting activities were aimed at opening the canopy and removing the ladder fuels to prevent another catastrophic wildfire such as the 2004 Deep Creek Fire and recreate a more fire-adapted ecosystem. The areas that were targeted were adjacent to U. S. Forest Service lands and were marked in conjunction with their plans for hazard fuel mitigation.

Data Sources and Techniques

"Living" snow fence. Photo by North Dakota Forest Service, used with permission.

Forest Inventory

Information on the condition and status of forests in North Dakota was obtained from the NRS-FIA program. Previous inventories of North Dakota's forest resources were completed in 1954 (Warner, and Chase 1956), 1980 (Jakes and Smith 1982), 1994 (Haugen et al. 1999), and 2005 (Haugen et al. 2009). Data from North Dakota's forest inventories can be accessed electronically on the DVD included with this report, or at: http://www.nrs.fs.fed.us/fia. For detailed information on inventory methods, see section "Statistics, Methods, and Quality Assurance" on the DVD.

National Woodland Owner Survey

Information about family forest owners is collected annually through the U.S. Forest Service's National Woodland Owner Survey (NWOS). The NWOS was designed to increase our understanding of owner demographics and motivation (Butler et al. 2005). Individuals and private groups identified as woodland owners by FIA are invited to participate in the NWOS. Data presented here are based on survey responses from 300 randomly selected families and individuals who own forest land in Kansas, Nebraska, North Dakota, and South Dakota. For additional information about the NWOS, visit: www.fia.fs.fed.us/nwos.

Timber Products Output Inventory

This study was a cooperative effort of the former Northeastern Research Station and NRS-FIA. Using a questionnaire designed to determine the size and composition of North Dakota's forest products industry, its use of roundwood (round sections cut from trees), and its generation and disposition of wood residues, North Dakota Forest Service personnel contacted via mail and telephone all primary wood-using mills in the State. 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 using regional conversion factors (Haugen et al. in press).

National Land Cover Data Imagery

Derived from Landsat Thematic Mapper satellite data (30-m pixel), the National Land Cover Dataset (NLCD) is a land cover classification scheme (21 classes) applied across the United States by the U.S. Geological Survey (USGS) and the U.S. Environmental Protection Agency (EPA). The NLCD was developed from data acquired by the MRLC Consortium, a partnership of Federal agencies that produce or use land-cover data. Partners include the U.S. Geological Survey, U.S. Environmental Protection Agency, U.S. Forest Service, and National Oceanic and Atmospheric Administration (Homer et al. 2004).

Mapping Procedures

Maps in this report were constructed using (1) categorical coloring of North Dakota county groups (major watersheds) 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-m pixel size) based on the spectral characterization of pixels and additional geospatial information; or (3) colored dots to represent plot attributes at approximate plot location.

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Denbigh Experimental Forest Scotch pine planting. Photo by Aaron Bergdahl, North Dakota Forest Service, used with permission.


SCOTCH PINE 196
SEED ORCHARD
RUSSIAN SEED SOURCES

DVD Contents

North Dakota's Forests 2010 (PDF)

North Dakota's Forests: Statistics, Methods, and Quality Assurance (PDF)

North Dakota Inventory Database (CSV file folder)

North Dakota Inventory Database (Access file)

Field guides that describe inventory procedures (PDF)

Database User Guides (PDF)

Previous Inventory Report (PDF)

Haugen, David E.; Harsel, Robert; Bergdahl, Aaron; Claeys, Tom; Woodall, Christopher W.; Wilson, Barry T.; Crocker, Susan J.; Butler, Brett J.; Kurtz, Cassandra M.; Hatfield, Mark A.; Barnett, Charles H.; Domke, Grant; Kaisershot, Dan; Moser, W. Keith; Lister, Andrew J.; Gormanson, Dale D. 2013. **North Dakota's Forests 2010**. Resour. Bull. NRS-76. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 52 p.

The second annual inventory of North Dakota's forests reports more than 772,000 acres of forest land with an average volume of more than 921 cubic feet per acre. Forest land is dominated by the bur oak forest type, which occupies more than a third of the total forest land area. The poletimber stand-size class represents 39 percent of forest land, followed by sawtimber (32 percent) and saplings/seedlings (28 percent). The volume of growing stock currently totals more than 341 million cubic feet. The average annual net growth of growing stock on forest land from 2006 to 2010 was approximately 6.8 million cubic feet per year. This report includes additional information on forest attributes, land use change, carbon stocks, timber products, forest health, and statistics, methods, and quality assurance of data collection. Detailed information on forest inventory methods and data quality estimates is included in a DVD at the back of this report. Tables of population estimates and a glossary are also included.

KEY WORDS: inventory, forest statistics, forest land, volume, biomass, carbon, growth, removals, mortality, forest health

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