South Dakota's Forests 2010

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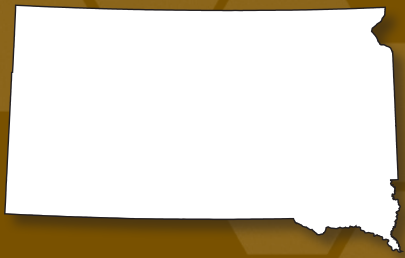
NRS-81



USDA United States Department of Agriculture

Forest Service

Abstract

The second full annual inventory of South Dakota's forests reports 1.88 million acres of forest land with an average volume more than 1,200 cubic feet per acre for all live trees. Forest land is dominated by the ponderosa pine forest type, which occupies 60 percent of the forest land area. Sixty-three percent of the forest land consists of large diameter stands, 15 percent medium diameter stands, 15 percent small diameter stands, and 7 percent is nonstocked. The average annual net growth of live trees on forest land from 2006 to 2010 is 40.2 million cubic feet per year while average annual removal is 25.8 million cubic feet per year. This report includes additional information on forest attributes, land use change, carbon, timber products, and forest health. Detailed information on forest inventory methods, data quality estimates, tables, and raw data can be found in the Statistics, Methods, and Quality Assurance section found on the DVD on the inside back cover of this report.

Acknowledgments

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Cover: Crazy Horse Memorial (background) in Black Hills National Forest. Photo by Gregory Josten, South Dakota Department of Agriculture, Resource Conservation and Forestry Division, used with permission.

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Foreword

I am pleased to introduce you to the latest report on South Dakota's forest resources. It is an important reference document outlining the results of the most scientific survey of our State's forest resources and it gives us a reliable snapshot of their health and vigor.

As you read through the document you will see some encouraging statistics. We have almost 12 percent more timber land in the State than we had in 2005. And, 90 percent of our trees are considered healthy with good tree vigor. That is great news!

However, this is offset by some findings that are less encouraging. Our aspen forest acres are shrinking. Our cottonwood forests are over-mature and there is little regeneration to take their place when these old monarchs die. And, the high annual tree mortality that is occurring in ponderosa pine, quaking aspen, and white spruce, combined with annual removals, are eroding standing inventories of these key species. This is not good news!

Without a systematic inventory of our Nation's forest lands, we would not know these trends were happening within our state. Consequently, these trends would continue and our future forest lands would be in jeopardy. With this information we can begin to make changes to policy and management that will avoid the pitfalls that are looming.

This gives you an idea of the value that I place on this report and the value of systematic forest inventories. I encourage you to study this document very closely and make your own conclusions on the current state of this important natural resource in South Dakota.

Sincerely,

Ray A. Sowers, State Forester

Contents

Highlights

On the Plus Side

- Forest land area increased from 1.7 million acres in 2005 to 1.9 million acres in 2010, continuing the increase seen in 2005. Timberland area increased from 1.6 million acres in 2005 to 1.8 million acres in 2010, and is at its highest level since the survey began in 1935.

- Between 2005 and 2010, forest land area increased by more than 30 percent in the Bad-Missouri-Coteau-James, Minnesota-Big Sioux-Coteau, and the White-Niobrara river basin areas (RBA). Forest land area also increased by 8 percent in the Belle Fourche-Grand-Moreau and by 6 percent in the Cheyenne RBA.

- Most species had a crown dieback percentage of 5 percent or less, and 90 percent of the crown densities are considered healthy and indicate good tree vigor. There has been no indication of ozone injury in South Dakota.

- Net volume of all live trees at least 5 inches d.b.h./d.r.c. increased by 5 percent between the 2005 survey and the 2010 survey.

- There is an average of 1.6 cubic feet of annual net growth of growing stock for every 1 cubic foot removed.

- Processing of industrial roundwood at South Dakota's primary forest products mills increased by 4 percent from 2004 to 2009. The harvesting of industrial roundwood from South Dakota's forest land increased by 13 percent during the same time period.

Areas of Concern

- Since 1996, the area of nonstocked forest land has increased by 33,000 acres and the area of poorly stocked stands has increased by 105,000 acres. Nearly 50 percent of all forest land falls into the poorly stocked or nonstocked stand categories.

- It is estimated that mountain pine beetle has affected 369,000 acres of forest land in South Dakota between 1996 and 2010.

- The net growth of quaking aspen is -1.3 cubic feet per year. This means that volume of quaking aspen lost due to mortality is greater that the volume gained due to the growth of trees.

- Due to high mortality and removals, white spruce sawtimber volume experienced a net inventory change (net growth minus removals) of -2.1 million board feet per year between 2005 and 2010.

- There is concern about the introduction of the banded elm bark beetle due to its potential as a vector of Dutch elm disease to other American elm trees.

- Bull and/or Canada thistle were recorded on nearly 25 percent of the plots that were sampled for invasive plant species. Invasive plant species can alter the forest through reducing forage, displacing native species, reducing biodiversity, and changing nutrient and hydrologic properties.

Arrowleaf balsamroot (*Balsamorhiza sagittata*) in Black Hills National Forest. Photo by Gregory Josten, South Dakota Department of Agriculture, Resource Conservation and Forestry Division, used with permission.

Issues to Watch

- More than 95 percent of the cottonwood forest type is in the large stand-size class with little regeneration. If this condition persists, cottonwood stands will become over-mature, giving way to other species that are currently in the understory.

- Fires and insects are the greatest causes of mortality in the State. If wildfires and/or insect infestations increase with concomitant increase in mortality, the ratio of net growth of growing stock to removals may be adversely affected.

- Ash trees are an important component of South Dakota's forests; this necessitates robust monitoring for the emerald ash borer.

- Of all the trees with crown dieback greater than 5 percent, nearly half were bur oaks. An average annual mortality rate of 1.0 million cubic feet per year for bur oak growing-stock on timberland resulted in a relatively low average net growth of bur oak growing-stock of only 0.3 million cubic feet per year.

- The increased use of bio-based material from agriculture crops to produce liquid transportation fuels and biodegradable products could adversely affect existing windbreaks or wooded strips along streams or rivers if they are removed for row crops. Most windbreaks or wooded strips don't qualify as forest under the Forest Inventory and Analysis program definition of forest land, but these other treed lands are an important resource for providing food and shelter to wildlife, livestock, and people, and for protecting soil, buildings, and roadways.

- Due to high mortality rates for ponderosa pine, quaking aspen, and white spruce, the average annual removals of growing stock for these species is greater than the average annual net growth of growing stock.

A Beginner’s Guide to Forest Inventory

Sica Hollow State Park. Photo by Gregory Josten, South Dakota Department of Agriculture, Resource Conservation and Forestry Division, used with permission.

What is a tree?

We all know a tree when we see one and we can agree on some common tree attributes. Trees are perennial woody plants having central stems and distinct crowns. In general, the Forest Inventory and Analysis (FIA) program, 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. A complete list of the tree species measured during this inventory can be found in "South 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?

Generally, a forest is an area with trees, and nonforested areas don't have trees. However, in South Dakota there are many narrow wooded strips along streams, rivers, and in windbreaks. This leads to the question where does the forest end and the prairie begin? It is an important question. The gross area of forest land or rangeland often determines the allocation of funding for certain State and Federal programs. Forest managers want more land classified as forest land, range managers want more land classified as prairie. Somewhere you have to draw the line.

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 treed area 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. Of the 1.9 million acres of forest land in South Dakota, 94 percent is timberland, 1 percent is reserved forest land, and 5 percent is other forest land.

• Timberland is forest land that is producing or is capable of producing crops of industrial wood and is not withdrawn from timber utilization by statute or administrative regulation. These areas are capable of producing in excess of 20 ft^3/acre/year of industrial wood in natural stands. Inaccessible and inoperable areas are included.

• Reserved forest land is forest land that is withdrawn from timber utilization through statute without regard to productive status. In South Dakota, the reserved forests are in the Black Elk Wilderness and Wind Cave National Park.

• Other forest land is forest land that is not capable of growing 20 ft^3/acre/year and is not restricted from harvesting. These sites are on extremely dry, or low, wet areas, or on very low-fertility sites.

Prior to 2001, only trees on timberland plots were measured. Therefore, while we can report volume on timberland for those inventories, we are unable to report volume on all forest land. With the implementation of the new annual inventory system in 2001 we are now able to report volume on all forest land, not just timberland. Because these annual plots have been remeasured upon completion of the second annual inventory in 2010, we are now able to report growth, removals, and mortality on all forest land, not just on timberland.

How many trees are there in South Dakota?

There are approximately 538.1 million live trees on South Dakota's forest land (give or take a few thousand) that are at least 1 inch in diameter at breast height (d.b.h., 4.5 feet above the ground), or for Rocky Mountain juniper, at least 1 inch in diameter at root collar (d.r.c.). We do not know the exact number because we only measured about 1 out of every 79,500 trees. In all 6,772 trees at least 1 inch in diameter were sampled on 366 forested plots. For information on sampling errors, see "South Dakota's Forests 2010: Statistics, Methods, and Quality Assurance," on the DVD in the inside back cover pocket of this bulletin.

How do you 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.

The volume of a tree can be precisely determined by immersing it in a pool of water and measuring the amount of water displaced. Less precise, but much cheaper, was the method used by the Northern Research Station. In this method several hundred trees were cut and detailed diameter measurements were taken along their lengths to accurately determine their volumes (for ponderosa pine–Myers 1964; for all other species - Hahn 1984). Statistical tools were used to model this data by species group. Using these models, we can produce individual tree volume estimates based on species, diameter, and tree site index. Site index is an expression of the quality of a site to grow specific trees.

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 USDA Forest Service Forest Products Laboratory developed specific gravity estimates for a number of tree species (U.S. Forest Service 1999). These specific gravities were then applied to tree volume estimates to derive estimates of merchantable tree biomass (the weight of the bole). It gets a little more complicated when you want to determine all live biomass. You have to add in the stump (Raile 1982) and the limbs and bark (Hahn 1984). We do not currently report the biomass in roots or foliage.

Forest inventory can report biomass as either green weight or oven-dry weight. Green weight is the weight of a freshly cut tree. Oven-dry weight is the weight of a tree with 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 directly the carbon in standing trees; it estimates forest carbon pools by assuming that half the dry biomass in standing live/dead trees consists of carbon. Additional carbon pools (e.g., soil, understory vegetation, belowground biomass) are modeled based on stand/site characteristics (e.g., stand age and forest type).

Comparing data from different inventories.

Data from new inventories are often compared with data from earlier inventories to determine trends in forest resources. This is certainly valid when comparing the 2005 inventory to the 2010 inventory. However, 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 the 1996 South Dakota inventory. While these changes will have little impact on statewide estimates of forest area, timber volume, and tree biomass they may have significant impacts on plot classification variables such as forest type and stand-size class. Some of these changes make it inappropriate to directly compare 2005 and the 2010 data tables with those published for 1996.

To many, the most important change is the border-to-border inventory of forest resources in South Dakota. Before 1996, both the Northern Research Station FIA (NRS-FIA) (formerly the North Central Research Station FIA program) in St. Paul, MN, and the Interior West FIA (IWFIA) (formerly the Intermountain FIA program) in Ogden, UT, inventoried South Dakota's forest resources. NRS-FIA inventoried that portion of the State east of the 103rd meridian. IWFIA inventoried western South Dakota (west of the 103rd meridian), including the Black

Hills National Forest (BHNF). In 1996, NRS-FIA inventoried all of South Dakota except for the BHNF (Leatherberry et al. 2000), which was inventoried by IWFIA in 1999 (DeBlander 2002). The portion of the Custer National Forest that is in South Dakota was inventoried again by IWFIA in 1997 (DeBlander 2001).

Another important change was the change in plot design. In an effort toward national consistency, a new national plot design was implemented by all five regional FIA units in 1999. The old NRS-FIA plot design used in the 1996 South Dakota inventory consisted of variable radius subplots. The new national plot design used in the 2000-2005 and the 2006-2010 inventories used fixed radius subplots. Both designs have their strong points but they often produce different classifications for individual plot characteristics.

A word of caution on suitability and availability…

FIA does not attempt to identify which lands are suitable or available for timber harvesting, especially since suitability and availability are subject to changing laws and ownership objectives. Just because land is classified as timberland does not necessarily mean it is suitable or available for timber production. Forest inventory data alone are inadequate for determining the area of forest land available for timber harvest since laws and regulations, voluntary guidelines, physical constraints, economics, proximity to people, and ownership objectives may prevent timberland from being available for timber production.

Forest Features

Black Hills National Forest. Photo by Gregory Josten, South Dakota Department of Agriculture, Resource Conservation and Forestry Division, used with permission.

Forest Land

Background

South Dakota, as one of the Great Plains States, has a relatively small area of forest land. Still, these lands are an important source of wildlife habitat, watershed protection, farmland protection, recreational opportunities, and economically valuable resources. Quantifying the amount of land occupied by forests is crucial to assessing the current status and trends in forest ecosystems. Fluctuations in the forest land base may indicate changing land use trends or forest health conditions.

What we found

The forest land area of South Dakota is estimated at 1.9 million acres, almost 4 percent of the total land area in South Dakota (Table 1, Fig. 1). Three-quarters of the forest land is located in the two western most river basin areas (RBA), the Belle Fourche-Grand-Moreau RBA and Cheyenne RBA, which account for only a third of the total land area in the State. Forest land area increased by 200,000 acres between 2005 and 2010 (Fig. 2). The first inventory of forest land in South Dakota in 1935 was designed primarily to determine the relation of farm forestry to other phases of farm management. From the 1935 inventory through the 2005 inventory, the area

Table 1.—Area of land, in thousand acres, by land status and river basin area, South Dakota, 2010.

River basin area	Total all land	Forest land: Total forest land	Forest land: Timberland	Forest land: Reserved forest land	Forest land: Other forest land	Nonforest land
Bad-Missouri-Coteau-James	17,364.8	164.2	135.0	--	29.2	17,200.6
Belle Fourche-Grand-Moreau	8,618.5	429.1	414.6	--	14.5	8,189.4
Cheyenne	8,519.6	997.8	956.1	30.2	11.5	7,521.8
Minnesota-Big Sioux-Coteau	7,831.3	67.1	59.6	--	7.4	7,764.2
White-Niobrara	6,069.8	224.9	199.2	--	25.6	5,844.9
Total	**48,403.9**	**1,883.0**	**1,764.6**	**30.2**	**88.2**	**46,520.9**

Columns and rows may not add to their totals due to rounding.

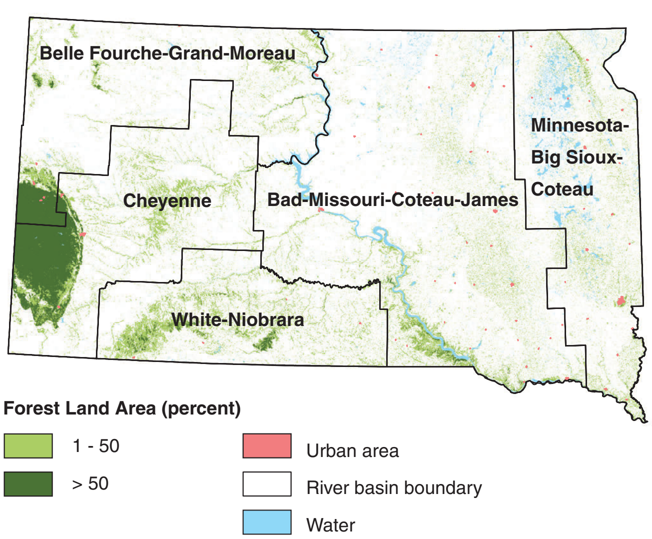


Figure 1.—Distribution of forest land by river basin area, South Dakota, 2010.

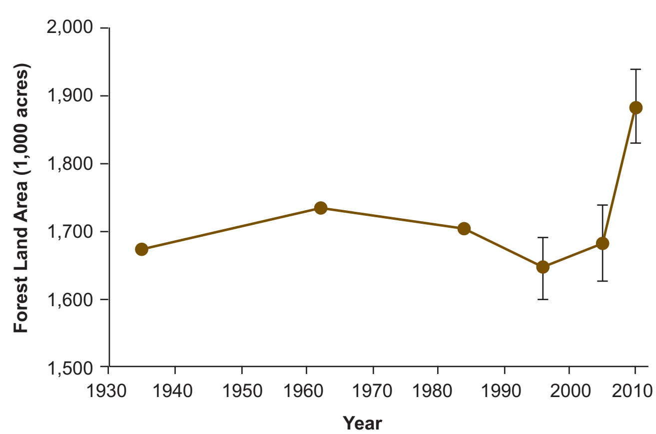


Figure 2.—Area of forest land by inventory year, South Dakota. (Error bars show the 68 percent confidence interval around the estimate; the sampling error estimate is not available from some survey years.)

of forest has remained around 1.7 million acres, only dropping to 1.6 million acres in the 1996 inventory. The 2010 inventory is the first inventory of South Dakota to report a significant increase.

What this means

Severe weather events during the first half of the 20th century affected South Dakota's forest land with both positive and negative consequences. The Dust Bowl of the 1930s prompted planting of many of the windbreaks, shelterbelts, and farm woodlots that are still present today. Seasonal flooding led the U.S.Congress to pass the Flood Control Act of 1944 which authorized the construction of dams on the Missouri River. The four dams that were constructed on the Missouri River in South Dakota created reservoirs that inundated an estimated 140,000 acres of bottomland forest (Leatherberry et al. 2000).

Today, forest land is still changing. Many of the windbreak and narrow wooded riparian strips are declining due to age, insects and disease, grazing, and the aerial application of agriculture herbicides. Dutch elm disease has taken a toll on the American elm, once a dominant species in riparian wooded areas. On the other hand, increased fire protection has allowed for the encroachment of the forest onto the rangeland and grasslands of the State. Much of the forest land increase in 2010 occurred on lands that previously did not have enough tree cover to be classified as forest land, such as pasture/rangeland with trees.

What the future holds for the forest land in South Dakota is hard to tell. The increased demand for liquid transportation fuels such as ethanol and biodiesel from short rotation agricultural crops could increase tillage and reduce forest area as more land is cleared for planting. Livestock farming may continue to decrease as the price to feed the animals increases. Less livestock grazing could encourage more of the borderline nonforest land areas to convert back to forest land.

Timberland

Background

Timberland has historically referred to forest land that is best suitable for forest products production. It excludes lands that are reserved from harvesting, may have another primary land management goal, such as wooded pastures, or produce such low volume of wood material that they are not viable for active forest management. Being classified as timberland though does not mean that it is available for harvesting. Steep and rough terrain, and more importantly, land owner plans and objectives may limit timberland from harvesting. More than 90 percent of South Dakota's forest land is defined as timberland (Fig. 3).

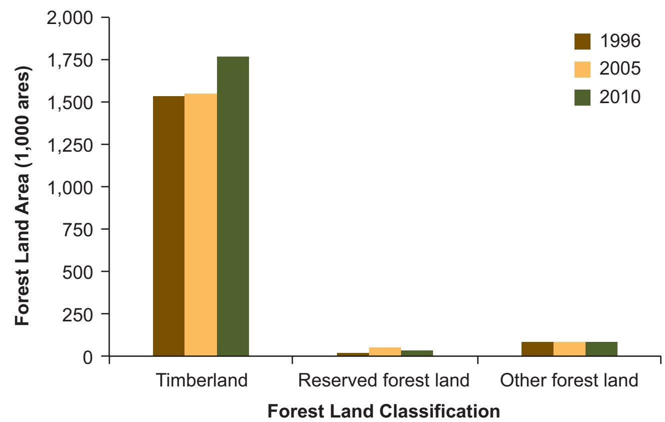


Figure 3.—Area of forest land classified as timberland, reserved forest land, and other forest land, South Dakota, 1996, 2005, and 2010.

What we found

Timberland, at 1.8 million acres, is at its highest level since the 1935 inventory. As with forest land, South Dakota's timberland is mostly publicly owned and is dominated by softwoods, mainly ponderosa pine. Hardwood forest types occur on only 22 percent of the timberland area in the State. Nearly two-thirds of the timberland area is stocked with large diameter stands (Fig. 4). Medium and small diameter stand sizes make up only 28 percent of the timberland area. The remaining 7 percent of the timberland in South Dakota is nonstocked. Nonstocked timberland is timberland that is less then 10 percent stocked with all live trees. These are areas that have been harvested or burned and the trees have not yet begun to regenerate back onto the site.

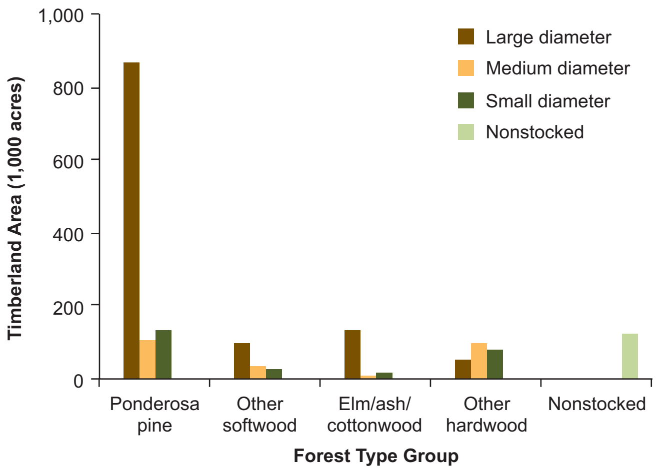


Figure 4.—Area of timberland by forest-type group and stand-size class, South Dakota, 2010.

What this means

Over the years, the ratio of large diameter stands to smaller diameter stands has continued to grow. In the extreme case of the white spruce forest type, for every 9.6 acres of large diameter-sized stands there is only 1 acre of small or medium diameter-sized stands. The elm/ash/cottonwood forest-type group is also high with 6.4 acres of large diameter-sized stands for each acre of small or medium diameter-sized stands. For ponderosa pine, this ratio is only slightly better at 3.7 to 1. For hardwoods, with the exception of the elm/ash/cottonwood and maple/beech/birch (where all the reported area is in the large diameter stand size) forest-type groups, the ratio of large diameter trees to medium and small diameter trees is reversed. The remaining hardwood forest types have a ratio of 1 acre of large diameter-sized stands for every 4.4 acres of small or medium diameter-sized stands.

From 2005 to 2010, the area of nonstocked and small diameter stands increased by nearly 35 percent. This is most likely the result of fires and harvesting. Past areas that have been burned over are now regenerating back to timberland. Harvesting operations to try to control the bark beetle remove the large- and medium-size trees, leaving small diameter-size stands, or nonstocked stands. The area of large diameter-size stands has also increased by 13 percent during the same time period, while medium diameter-size stands have decreased by almost 5 percent.

Other Treed Land

Background

South Dakota is approximately 4 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 have 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*), which, since being identified in 2002 near Detroit, MI, 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 (as of October 2010).

In response to these concerns, state forestry agencies in the Plains States, with funding assistance from the U.S. Forest Service's State and Private Forestry, began a project called the Great Plains Tree and Forest Invasives Initiative (GPI) (Lister et al. 2011). Objectives of the GPI include a characterization of the existing NFT resource with an inventory, the identification of EAB mitigation needs and utilization opportunities, and the development of educational materials to help land managers and land owners 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 198 urban and 300 rural plots were collected in South Dakota during 2008 and 2009. One of the goals of the GPI is to assess the ash resource in the Plains States.

What we found

Ash is the fifth most abundant forest land tree species, with an estimated 22 million ash trees that are 1-inch diameter or greater. However, GPI findings indicate that ash is the most abundant tree species in nonforest areas, with an estimate of 24 million trees. In fact, the species compositions of forest and nonforest areas (with respect to species abundance) are very different (Table 2). Not surprisingly, ponderosa pine is not as strong a component in nonforest areas as it is in forested areas. Along the same lines, ash is a very strong component of nonforest areas, due in large part to its extensive planting (Ball et al. 2007).

The GPI inventory also found species composition differences when comparing urban and non-urban areas (Table 2). Ponderosa pine emerges as a strong component of urban areas, which may 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. There can thus be large natural areas surrounding some of the smaller population centers designated by the U.S. Census Bureau as urban places. In any case, ash is a strong component in both urban and rural areas.

Of the trees in nonforest areas, 49 million (66 percent) perform some kind of a windbreak or buffer strip function, with approximately 90 percent being associated with farming or livestock. The remaining windbreak trees are either in riparian areas, wildlife plantings, or other natural or semi-natural, narrow wooded strips. Species compositions of windbreak and nonwindbreak areas are similar, with some notable exceptions. For example, there is a much higher percentage of ash trees in windbreaks due to extensive plantings. Willows, on the other hand, likely occur with a higher frequency in

Table 2.—Number of live trees (at least 1 inch d.b.h./d.r.c.), in thousand trees, on forest land and nonforest land by species, South Dakota, 2010.

		Nonforest land		
Species/species group	**Forest land**	**Total nonforest land**	**Rural nonforest land**	**Urban nonforest land**
Ponderosa pine	330,959	3,660	2,467	1,192
Redcedar/juniper spp.	30,799	11,171	11,116	55
Bur oak/white oaks	29,646	2,562	2,306	257
White spruce	26,547	--	--	--
Eastern hophornbeam	25,976	--	--	--
Ash spp.	21,538	24,305	23,158	1,147
Aspen spp.	20,888	--	--	--
Paper birch	15,676	--	--	--
Elm spp.	9,813	11,365	10,860	504
Boxelder	8,030	4,639	4,354	284
Cottonwood and poplar spp.	2,649	3,352	3,223	128
Willow spp.	593	5,597	5,074	523
Cherry and plum spp.	8	2,585	2,429	156
Total	**519,872**	**69,236**	**64,987**	**4,246**

nonwindbreak areas due to regeneration in riparian areas (Fig. 5). Differences in species composition are likely due to a combination of chance, historic land use, and the effects of natural factors such as proximity to streams.

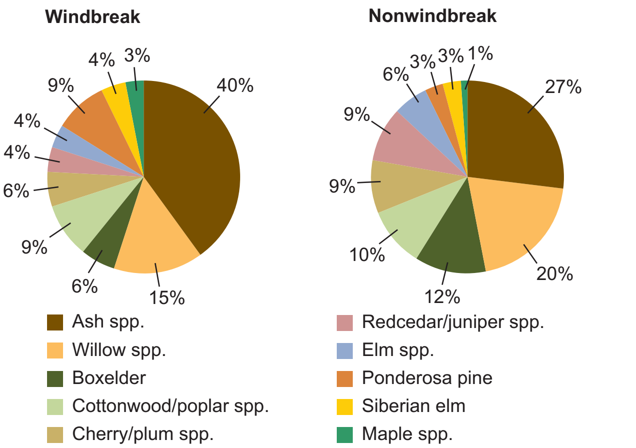
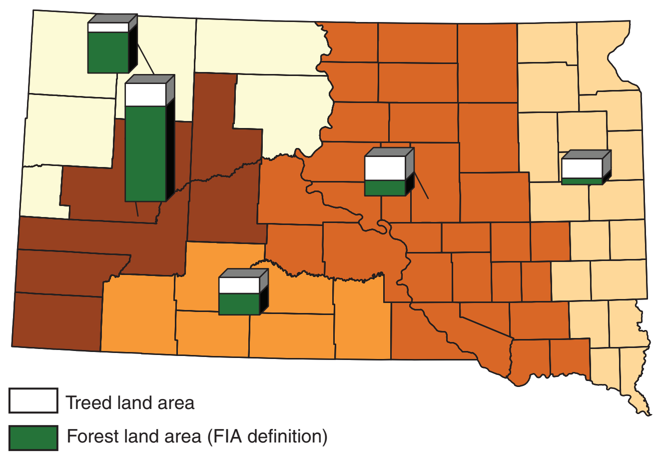


Figure 5.—Percentages of the 10 most common tree species as a proportion of all trees in windbreak and nonwindbreak areas, South Dakota, 2010.

There are almost 1 million acres of nonforest treed land in South Dakota, divided among several land uses (Table 3, Fig. 6). Nonforest treed land surrounding agriculture represents the largest proportion of the nonforest tree land base, ranging from 39 percent in the Minnesota-Big Sioux-Coteau watershed to 92 percent in the White-Niobara watershed. The U.S. Department of Agriculture periodically conducts an agricultural census and generates maps of estimates of the occurrence of different types of agricultural land use. This map product, called the Cropland Data Layer (CDL) (U.S. Department of Agriculture 2006), was combined with the nonforest tree plots in a geographic information system (GIS)



River Basin Area	Forest land area (1,000 acres)	Treed land area (1,000 acres)
Belle Fourche-Grand-Moreau	429	100
Minnesota-Big Sioux-Coteau	67	205
White-Niobrara	225	169
Bad-Missouri-Coteau-James	164	253
Cheyenne	998	242

Figure 6.—Proportion of treed land and forest land by river basin area, South Dakota, 2010.

Table 3.—Area of other treed lands, in thousand acres, by river basin area and land use, South Dakota, 2010.

		River basin area				
Land use	Total	Belle Fourche-Grand-Moreau	Cheyenne	White-Niobrara	Bad-Missouri-Coteau-James	Minnesota-Big Sioux-Coteau
Agriculture	637	85	179	155	140	79
Other rural nonforest	151	7	17	11	68	47
Residential	63	--	6	2	23	32
Farmstead or rural home site	58	8	13	--	4	33
Marsh-wetland	13	--	5	--	4	4
Institutional-cemetery	13	--	8	--	2	3
Transportation-utility	9	--	4	--	4	2
Park	8	--	--	2	7	--
Commercial-industrial	6	--	5	--	--	2
Multifamily residential	5	--	--	--	2	3
Open space-Vacant	5	--	5	--	--	--
Total	**968**	**100**	**242**	**169**	**253**	**205**

to produce summaries of nonforest tree data by type of agricultural use. Results suggest that the majority of nonforest treed land is surrounded predominantly by grassland, pasture, rangeland, and other noncrop land uses (Table 4). Nonforest trees are not distributed proportionally across all CDL land use classes found in the State. For example, there are proportionally more nonforest trees found around corn fields than the proportion of area of this crop type in the State would suggest. This situation is reversed for soybean fields, suggesting crop-specific differences in either historical tree planting or land management practices.

Table 4.—Total number of trees by land use class from the USDA National Agricultural Statistics Service's Cropland Data Layer, South Dakota, 2010.

Cropland Data Layer land use class	Number of trees (1,000 trees)	% Total number of trees	% Total area of class on map
Grass, pasture, range, nonagricultural areas, waste, farmstead	42,780	57%	58%
Corn, all	10,623	14%	9%
Developed	7,222	10%	4%
Wetlands or water	5,109	7%	5%
Soybeans	3,160	4%	8%
Woodland and shrubland	3,810	5%	7%
Spring wheat	1,019	1%	3%
Alfalfa	1,016	1%	1%
Other grains and crops or barren	0	0%	5%
Total	**74,738**	**100%**	**100%**

What this means

FIA provides valuable information on various site variables across all lands with detailed tree site variables collected on lands meeting forest definitions. 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, thus different management approaches should apply. In particular, the ecology of nonforest treed land is vulnerable to perturbation by outbreaks of the EAB. The information obtained from the GPI can be used to promote wise windbreak stewardship, for example, which might include monitoring windbreaks for EAB infestation, removal of dead or dying trees and replacement with nonsusceptible 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, which can include support for wildlife populations, windbreak functions, energy savings, and forest product industry development.

Land Use Change

Background

FIA characterizes land area using several broad categories, including forest, agriculture, and developed land. The conversion of forest land to other uses is referred to as gross forest loss while the conversion of nonforest land to forest is known as gross forest gain. The magnitude of the difference between gross loss and gain is defined as net forest change. By comparing the land uses on current inventory plots with the land uses recorded for the same plots during the previous inventory, we can characterize forest land use change dynamics. Understanding land use change dynamics helps land managers make informed policy decisions. Furthermore, forest change estimates are vital to scientists studying the carbon cycle and its relationship to climate change.

Although forests cover only 4 percent of the land area in South Dakota, they are a critical resource and offer a wide range of benefits. Tree and vegetation cover limit soil loss due to wind and water erosion. Riparian forests serve as stream buffers protecting and clarifying the State's water resources. Forests provide habitat for forest-dwelling species and provide economic and other benefits for humans. Although the total area of forest land has been increasing in South Dakota, some areas of the State have experienced forest loss. Urban development is occurring at a rapid pace in the United States. Nowak and Walton (2005) predicted that the area of urban land in the United States would nearly triple from 2000 to 2050. Although the rates of development and population growth are below the national average, South Dakota has the largest population growth rate in the Midwest according to the 2010 U.S. Census and certain areas of the State are under increasing pressure from development.

What we found

The land area in South Dakota is dominated by pasture and cropland. These agricultural land uses, along with urban and other nonforest land use cover 96 percent of the State's land area. Most of the FIA plots in South Dakota either remained forested or stayed in a nonforest land use (3.4 percent and 96.1 percent, respectively), and only about 0.5 percent experienced either a forest loss or gain from 2005 to 2010 (Fig. 7).

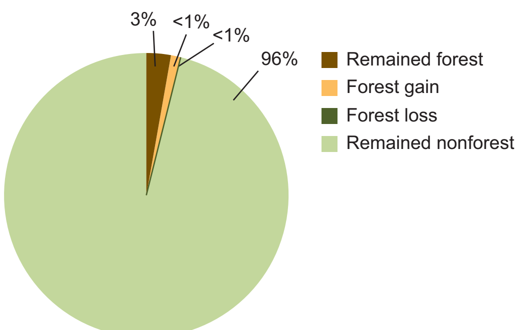


Figure 7.—Proportion of land that was unchanged, or showed forest loss and forest gain, South Dakota, 2005 to 2010.

According to the FIA remeasurement data, from 2005 to 2010 South Dakota lost 40,000 acres of forest land, which was offset by a gain of approximately 240,000 acres during the same time period (Fig. 8). This resulted in a net forest gain of 200,000 acres or a 12 percent increase. Seventy-six percent of forest gain in South Dakota is from agricultural land converting to forest. In some areas, especially in land adjacent to streams, trees have been planted to protect the State's water resources. In other areas, pasture and cropland has been left idle and is regenerating naturally. Only a small portion of the forest area that was lost was converted to developed land uses. Unlike forest changes into and out of agricultural land, forest conversion to development is likely a permanent loss.

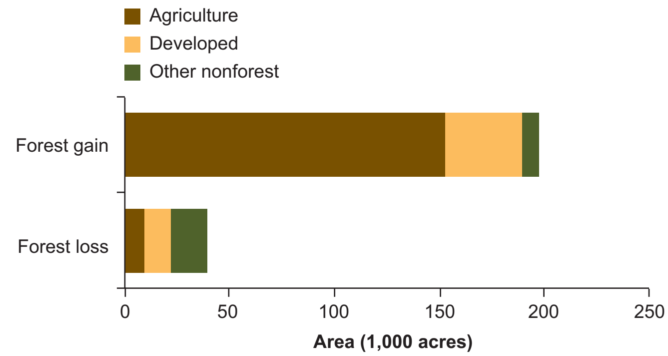


Figure 8.—Gross forest loss and forest gain by land use category, South Dakota, 2005 to 2010.

We can use the FIA data to characterize the forest land that has been lost and gained to see if it differs from the characteristics of forest land in all of South Dakota. The forests of South Dakota are dominated by stands in the large diameter class with more than 60 percent of the total forest land area in this stand-size class. The forest land that was lost had only 36 percent of its area in large diameter stands, suggesting that small and medium diameter stands may be disproportionately more susceptible to forest loss.

Figure 9 shows the distribution of remeasured plots across South Dakota highlighting plots where forest land has been lost and gained. Although the total amount of forest land is limited, it is concentrated in the Black Hills region and in the area around streams and rivers.

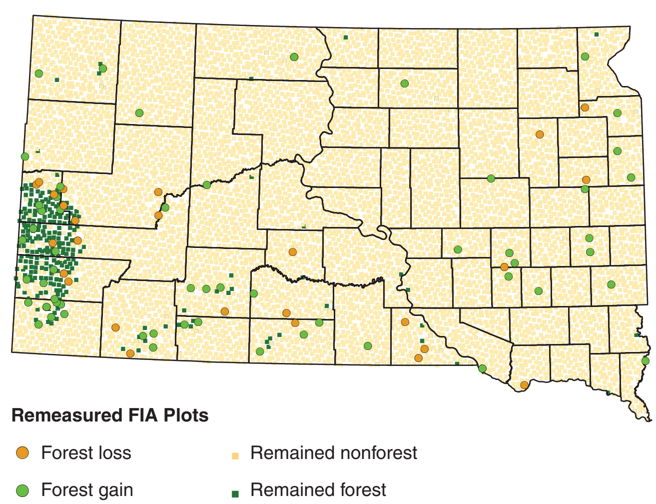


Figure 9.—Distribution of remeasured inventory plots showing forest gains and losses, South Dakota, 2005-2010. Plot locations are approximate.

Forest changes west of the Missouri River appear to be concentrated in the Black Hills forest and along the Cheyenne and White Rivers and their tributaries. Forest change east of the Missouri River is dominated by forest gains and is more evenly distributed north to south.

What it means

Agriculture is the dominant land use in South Dakota and gains/losses in pasture and cropland appear to drive land use change dynamics in the State. An examination of the pattern of forest losses and gains in South Dakota reveals that these changes generally occur near rivers. Riparian forest land is especially important as trees help conserve and protect the State's water resources. Agroforestry efforts promote the maintenance of tree cover in the form of windbreaks and forest buffers that help sustain a high agricultural output while conserving and protecting South Dakota's soil and water resources. These forested areas are also important to South Dakota's wildlife populations. Riparian forests often connect to form wildlife corridors and allow for species movement.

There was relatively little loss of forest land in South Dakota. The forest land that was lost to agricultural uses may be a result of increased demand for agricultural-based biofuels. Overall, gains in forest land have outpaced forest losses and South Dakota appears to be moving toward greater conservation and valuation of the State's forest resources.

Ownership

Background

From the Black Hills National Forest in the western part of the State to a family with a few acres in the eastern part of the State, forest ownership varies dramatically across South Dakota. The fate of South Dakota's forests lies in the hands of the people, organizations, and governing bodies who own them. The goods and services produced and provided by forests are a function of the forest land owners' objectives, opportunities, and constraints. Continued pressures from a changing society are altering what landowners can and will provide.

What we found

Sixty percent of the forest land in South Dakota is in public ownership, with nearly 55 percent in Black Hills and Custer National Forest ownership (Fig. 10). The South Dakota portion of the Black Hills National Forest is located in the Cheyenne and Belle Fourche-Grand-Moreau RBAs, and the South Dakota portion of the Custer National Forest is in the Belle Fourche-Grand-Moreau RBA. The remainder of the public forest land is owned by other federal, State, county, and other local governments.

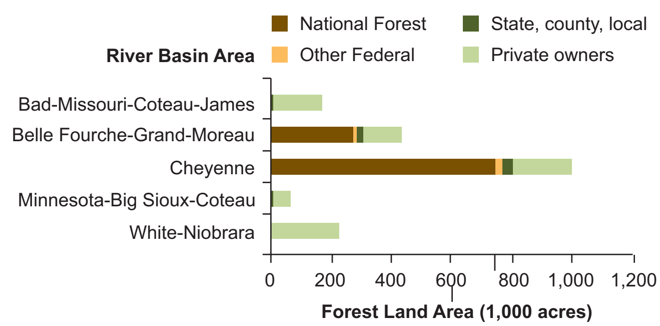


Figure 10.—Area of forest land by river basin area and ownership, South Dakota, 2010.

Thirty percent of the privately owned forest land is located in the White-Niobrara RBA; 25 percent in the Cheyenne RBA; 21 percent in the Bad-Missouri-Coteau-James RBA; 16 percent in the Belle Fourche-Grand-Moreau RBA; and 8 percent in the Minnesota-Big Sioux-Coteau RBA. There was no Federal ownership of forest land in the Bad-Missouri-Coteau-James, Minnesota-Big Sioux-Coteau, and the White-Niobrara RBAs.

What this means

Public forests are a critical part of South Dakota's natural resource wealth. They provide access to outdoor education and recreation, protect land and water resources, provide wildlife habitat, and supply timber to the forest products industry. But, nearly 99 percent of all public forests are in the Belle Fourche-Grand-Moreau and Cheyenne RBAs. This means that the easy access to outdoor education and forest recreation may be limited by distance for many areas of the State.

Ownership trends of hardwood and softwood forest types is nearly reversed. More than 70 percent of the softwood forest types are found on publicly owned forest land while 80 percent of the hardwood forest types are found on privately owned forest land (Fig. 11). Nearly 80 percent of the nonstocked forest land is located on public lands.

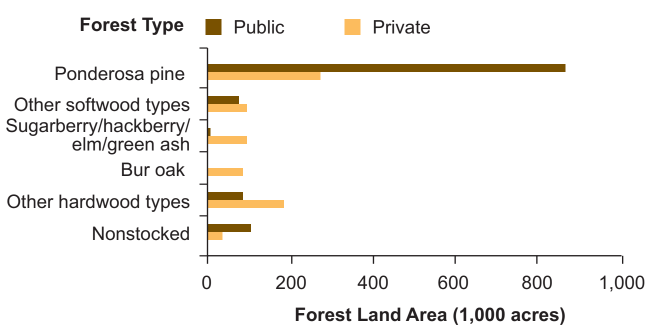


Figure 11.—Area of forest land by forest type and ownership group, South Dakota, 2010.

There is also a difference in the growth, mortality, and removal rates of forest land between privately and publicly owned forest land. Sixty percent of the average annual net growth of live trees at least 5 inches d.b.h./d.r.c. on forest land occurs on private ownerships. But, 65 percent of the mortality and 75 percent of the removals occur on public ownerships.

Family Forest Ownership Across the Great Plains

Background

It is the owners of the forest land who 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 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 40 percent in South Dakota (Fig. 12). Of these private acres, most (89 percent) are owned by families, individuals, and other unincorporated groups, collectively referred to as family forest owners. A total of 191,000 family forest owners control 3.9 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. 13). 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 their farm, aesthetics, family legacy, and protection of nature (Fig. 14).

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.

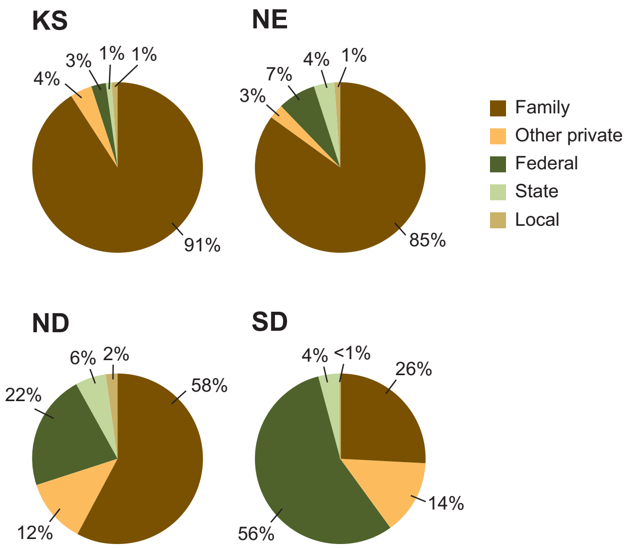


Figure 12.—Forest ownership in Kansas, Nebraska, North Dakota, and South Dakota, 2006.

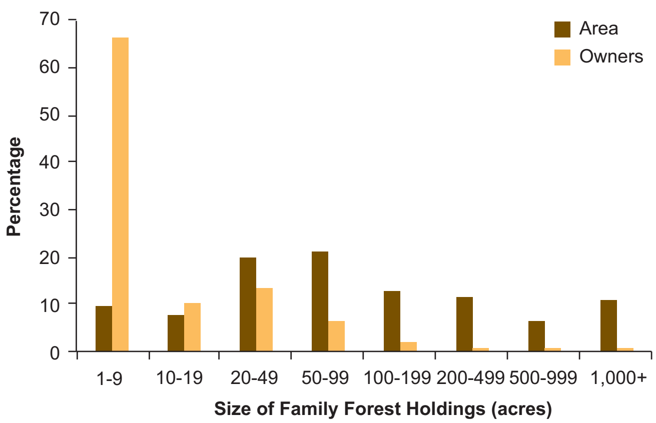


Figure 13.—Size of family forest holdings in the Plains States, 2006.

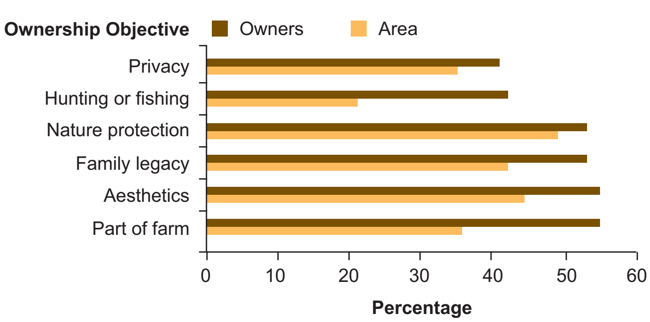


Figure 14.—Primary ownership objectives of family forest owners in the Plains States, 2006.

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 on to 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 averse to harvesting and other activities in the woods. It is important to provide programs that meet the owners' needs.

Tree Species Composition

Background

Forest composition is constantly evolving. Influenced by the presence or absence of disturbances such as timber management, insect outbreaks, fires, extreme weather, and invasive species, the current state of species composition reflects historical and environmental trends. As a result, the composition of species in a forest is an indicator of forest health, growth, succession, and need for stand improvement (i.e., management). Knowledge of the distribution of species allows for the measurement and prediction of change.

What we found

There are 538 million trees over 1-inch d.b.h./d.r.c. on forest land, Ponderosa pine is the most common species, with more that 330 million trees, or 62 percent of all trees (Fig. 15). Bur oak and Black Hills spruce (white spruce) are second and third, respectively.

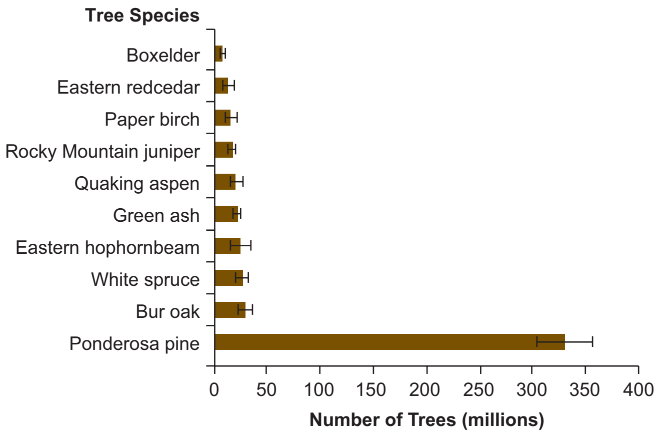


Figure 15.—Ten most common tree species on forest land, South Dakota, 2010.

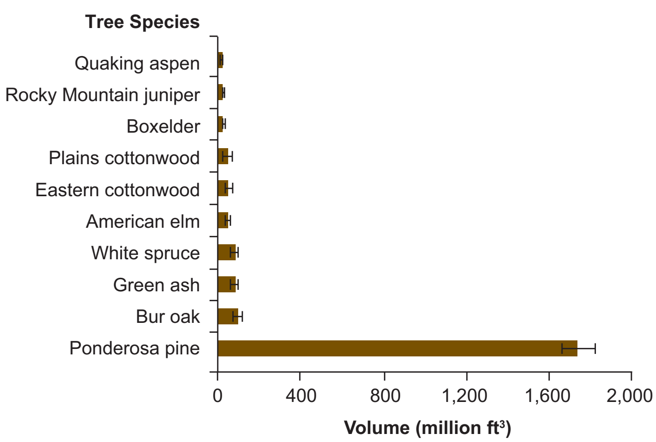


Figure 16.—Top 10 tree species by volume on forest land, South Dakota, 2010.

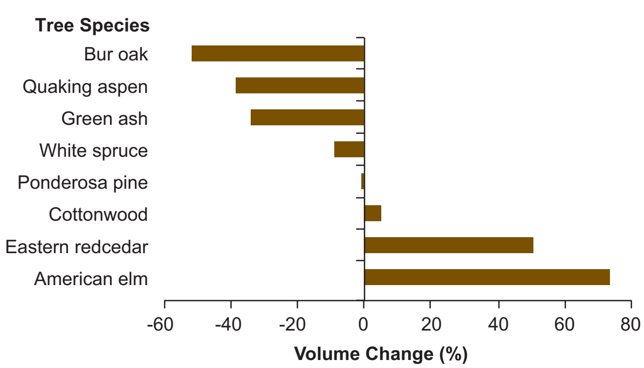


Figure 17.—Change in growing-stock volume between 2005 and 2010 for species with at least 10 million cubic feet total volume on timberland, South Dakota.

In terms of the total statewide live-tree volume on forest land, ponderosa pine again dominates the State with 1.7 billion cubic feet, or more than 75 percent of the total volume (Fig. 16). For several tree species, there has been tremendous change in growing-stock cubic feet volume on timberland, most notably, American elm and eastern redcedar, which have increased in volume by roughly 75 and 50 percent, respectively, since 2005 (Fig. 17). In contrast, bur oak and quaking aspen have lost roughly 50 and 40 percent respectively, of their growing-stock volume on timberland since 2005.

What this means

As evidenced by inventory results, the species composition of South Dakota's forests is constantly evolving with some species increasing their dominance while others wane. The major causes for the decreases in growing-stock volume for bur oak, quaking aspen, and green ash is mortality. There were also many trees that were classified as growing-stock trees during the 2005 inventory cycle, that were not classified as growing-stock trees during the 2010 inventory cycle because of damage, disease, or poor form.

The increase of growing-stock volume for American elm can be attributed to sapling-size trees growing into pole- or medium-size trees, thus moving into the growing-stock size tree category. The increase of growing-stock volume for eastern redcedar is the result of encroachment of the species into rangeland and becoming established in the understory of other forest types.

Stand-size Class

Background

Forests contain trees of various sizes. Stand size is a measure of the average diameter of the dominant trees in a stand. There are three stand-size classes: large diameter (i.e., sawtimber; softwood trees at least 9 inches d.b.h./d.r.c. and hardwoods at least 11 inches d.b.h.); medium diameter (i.e., poletimber; trees 5 inches d.b.h. /d.r.c. to large diameter size); and small diameter (i.e., saplings/seedlings; trees less than 5 inches d.b.h. /d.r.c.). Nonstocked stands may have trees in any size class but do not have enough trees present to be classified as a stocked stand, so they are not grouped into a stand-size class. Changes in the distribution of stand-size class over time, provide information about forest sustainability and succession, wood potentially available for products, wildlife habitat, and recreation potential.

What we found

Almost 65 percent of all the forest land in South Dakota is in the large diameter size class. The Bad-Missouri-Coteau-James RBA had the most balanced size class distribution of all the RBAs, with 33 percent of the forest land in the large diameter size class, 39 percent in the medium diameter size class, and 17 percent in the small diameter size class, but this area also had the greatest percent of the forest land area in the nonstocked size class category, with 11 percent of all the forest land classified as nonstocked. All the other RBAs in the State had more than 60 percent of the forest land area in the large diameter stand-size class (Fig. 18).

More than 90 percent of the forest land area that was classified as a cottonwood or a white spruce forest type was in the large diameter size class. Neither of these forest types had any forest land that was classified as small diameter size class (Fig. 19). More than 70 percent of the area in the eastern redcedar forest type and almost 60 percent of the area in the aspen forest type were in the small diameter size class.

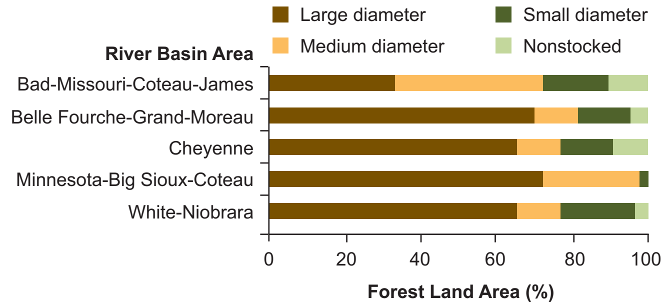


Figure 18.—Percentage of forest land in each size class, by river basin area, South Dakota, 2010.

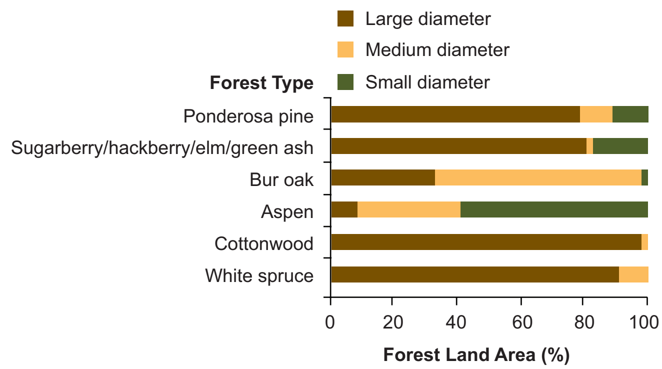


Figure 19.—Percentage of forest land in each stand-size class by the top six forest types (by area), South Dakota, 2010.

What this means

Over the years, forest trees in South Dakota have grown. Looking at the area of timberland, large diameter size stands have continued to increase while the area of medium diameter size stands has decreased (Fig. 20). The high proportion of total area in large-diameter stands indicates a maturing forest. Since 1962, there has been a 40 percent increase in the area of large diameter size stands on timberland. At the same time, medium diameter stands on timberland have decreased by 63 percent. Although there is nearly four times the area of timberland in the small diameter size class in 2010 as there was in 1962, this size class still only make up 15 percent of the total timberland area.

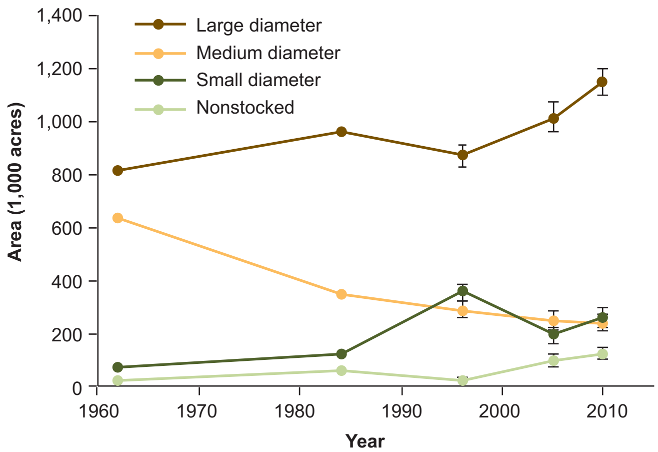


Figure 20.—Area of timberland by stand-size class and inventory year, South Dakota. Error bars show the 68 percent confidence interval around the estimate, for years data was available.

The cottonwood and cottonwood/willow forest types are extreme examples of forest types that have reached maturity. Ninety-eight percent of the combined total areas of these two forest types are in the large diameter size class with no sampled areas found to contain any small diameter size class stands. Cottonwoods require periodic flooding to expose bare soil for the seeds to germinate. Flood control measures on the rivers in South Dakota have eliminated most of the flooding, so regeneration is lacking in the cottonwood forest types. Instead, other species, such as ash, elm, and eastern redcedar are becoming established in the understory and replacing the cottonwood as it dies out.

Forest Stand Density

Background

The density of forest stands across South Dakota may indicate the stages of stand development and the site occupancy of forests. Determining stages of stand development helps us assess the future growth or mortality of forest resources. Stand density may be useful as an indicator of susceptibility of stands to insect or disease problems, or the need for harvesting trees or other activities that promote growth in stands.

What we found

An acre of forest land in South Dakota supports an average of 286 live trees over 1 inch d.b.h./d.r.c. The mixed upland hardwoods forest type, with an average of 758 live trees per acre, had the greatest number of trees per acre (Fig. 21). The other hardwoods forest type had the lowest number of live trees per acre, with an average of 59. Nonstocked forest land averaged only 17 live trees over 1 inch d.b.h./d.r.c. per acre. Both number of trees and stand-size class are important factors used to calculate volume of wood per acre. The statewide average volume of live trees (at least 5 inches d.b.h./d.r.c.) per acre of forest land is 1,214 cubic feet of wood per acre. The cottonwood/willow forest type, which has most of its area in sawtimber-size stands, has the greatest average volume per acre at 2,313 cubic feet of wood per acre, even though it has one of the lowest averages for number of trees per acre (Fig. 21).

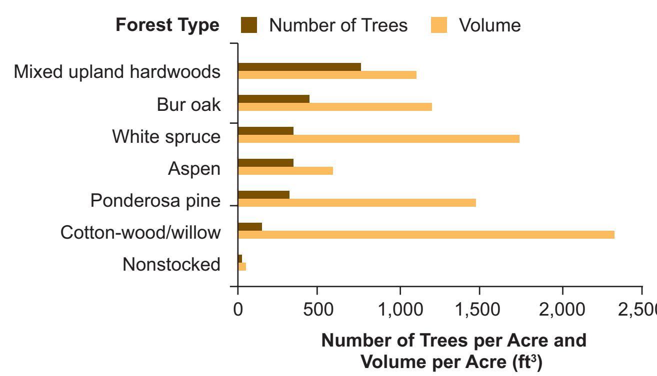


Figure 21.—Number of live trees 1 inch or greater per acre of forest land, and cubic foot volume of live trees 1 inch or greater per acre of forest land, for selected forest types in South Dakota, 2010.

Basal area—the cross sectional area of trees measured 4.5 feet above the ground—serves as another measure of stand density. Sixty percent of the forest land in South Dakota had a basal area of 80 square feet per acre or less (Fig. 22). More than 80 percent of the forest land in the Bad-Missouri-Coteau-James and the White-Niobrara RBAs had 80 square feet per acre or less.

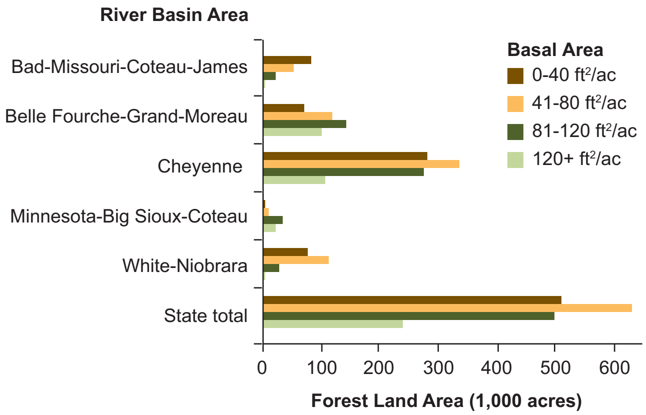


Figure 22.—Area of forest land by basal area and river basin area, South Dakota, 2010.

What this means

A diversity of forest stand densities exists across South Dakota. Some factors leading to the low stocking levels are adverse site conditions that limit tree regeneration and growth such as sites that receive low rainfall amounts. Other stands, such at those in the cottonwood forest type, are maturing with little or no regeneration. As the older trees die without regeneration to replace them, the stands become sparse. Stands that have more trees per acre than what would be considered fully stocked based on species and tree size are overstocked. Overstocked stands are at increased risk to insect and disease problems because the overcrowded trees become stressed due to competition with neighboring trees for moisture, sunlight, and nutrients. The most susceptible stands to mountain pine beetle attack are those with trees more than 8-inches in diameter and a basal area greater than 150 square feet per acre.

Biomass

Background

Tree biomass is the total dry weight of all live aboveground components of forest trees. As with measures of South Dakota's forest acreage, measuring total biomass and its allocation among stand components (e.g., small-diameter trees, limbs, and stumps) helps us understand the components of a forest stand and the resources available for different uses (e.g., wildlife habitat, carbon sequestration, or biofuels).

What we found

There is an estimated 45.3 million dry tons of total live aboveground tree biomass on forest land in South Dakota in 2010. Between 2005 and 2010, aboveground hardwood tree biomass increased by almost 20 percent while aboveground softwood tree biomass increased by less than 5 percent (Fig. 23). Most of the forest biomass is in growing-stock tree boles (64 percent) followed by growing-stock tree stumps, tops, and limbs (15 percent), and nongrowing-stock tree boles (12 percent) (Fig. 24). Although the distribution of forest biomass across South Dakota is highly correlated with the occurrence of forest area, the largest quantities of forest biomass can be found in the northern Black Hills (Fig. 25).

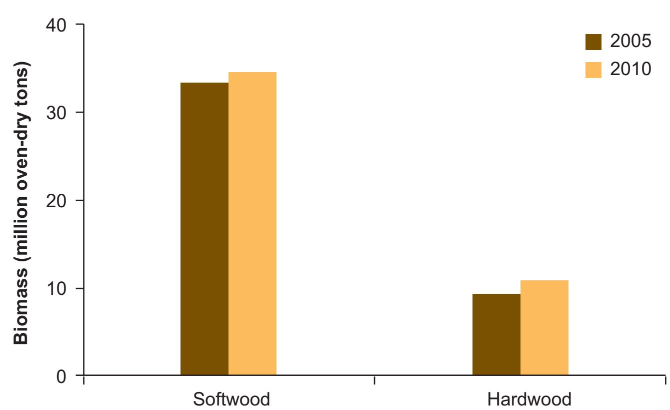


Figure 23.—Aboveground biomass of all live trees (at least 1 inch d.b.h./d.r.c.) by hardwood and softwood, South Dakota, 2005 and 2010.

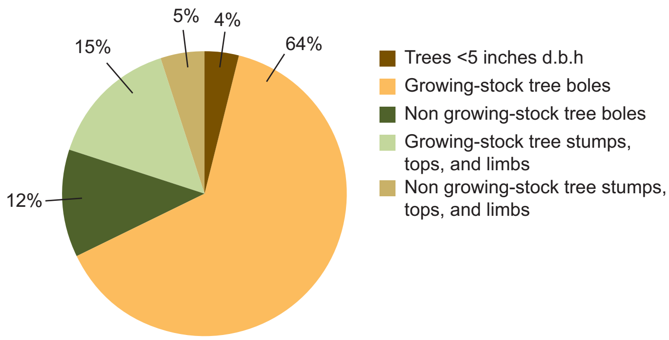


Figure 24.—Proportion of biomass by tree component on forest land, South Dakota, 2010.

What this means

The increases in both forest area and forest growth have resulted in a sustainable resource of total forest biomass. Because most forest biomass is found in the boles of growing-stock trees on timberland, the management of forest land strongly influences the future of not only the biomass resource but also the carbon cycles and future wood availability. Given the increasing demand to manage forest biomass components both carbon and bioenergy, the monitoring of South Dakota's forest biomass has become even more critical.

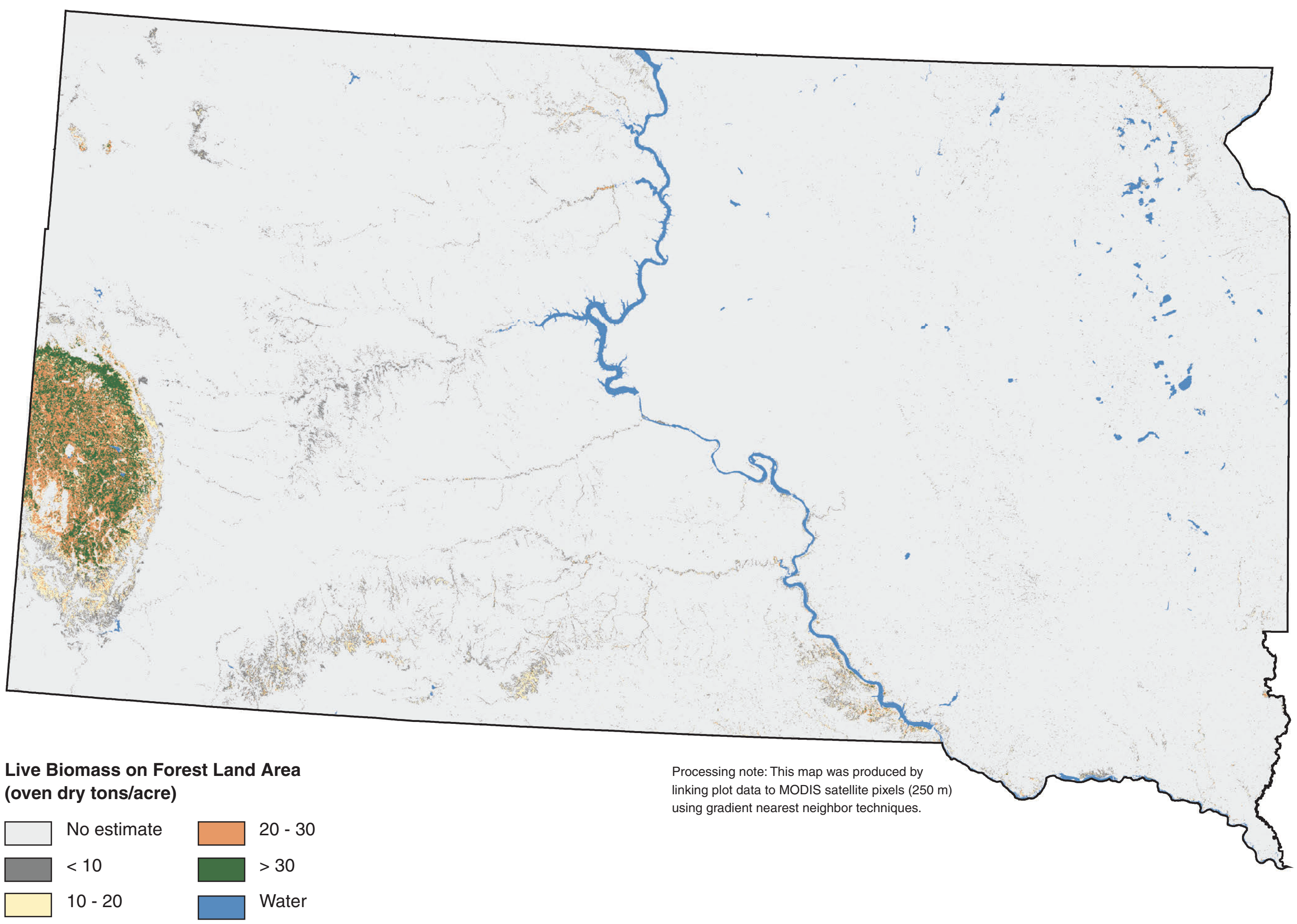


Figure 25.—Distribution of biomass on forest land, South Dakota, 2010.

Forest Growth

Background

The capacity of forests to grow wood is an indicator of health, vigor, and development stage of trees in stands. Forest growth is expressed as average annual net growth, where net growth is equivalent to gross growth minus mortality. Average annual net growth represents the annual increment of volume before the impact of removals between the two most recent inventories, 2005 and 2010 for this report.

What we found

The average annual net growth of live trees on forest land from 2005 to 2010 was 40.2 million cubic feet per year. During the same time period, the average annual net growth of growing-stock trees on timberland was 38.2 million cubic feet per year. Privately owned forest land accounted for 60 percent of the average annual net growth, but only 43 percent of the annual net growth on timberland (Fig. 26). Almost 40 percent of the growth on forest land occurred in the Cheyenne RBA, but this RBA accounted for almost 60 percent of the growth on timberland (Fig. 27).

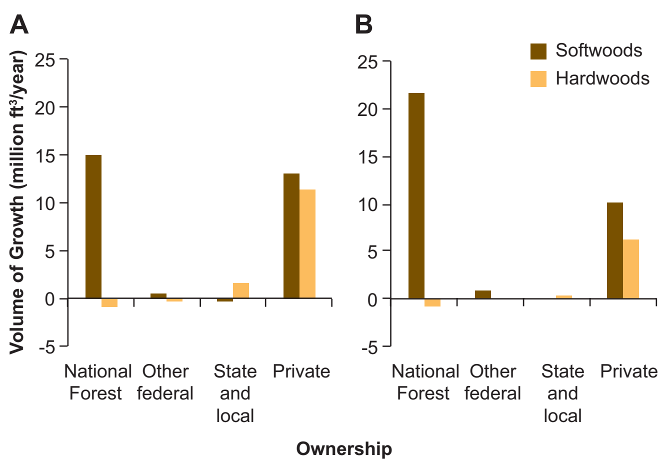


Figure 26.—Average annual net growth of live trees on forest land (A) and average annual net growth of growing-stock trees on timberland (B) by ownership group and softwoods and hardwoods in South Dakota, 2010.

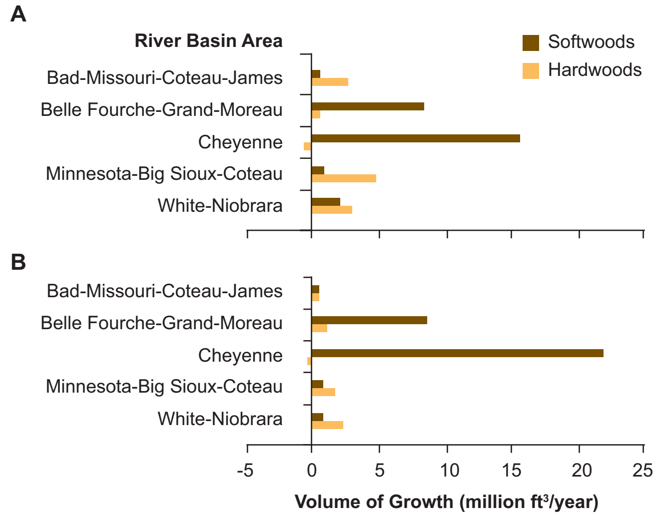


Figure 27.—Average annual net growth of trees on forest land (A) and average annual net growth of growing-stock trees on timberland (B) by river basin area and softwoods and hardwoods, South Dakota, 2010.

What this means

The net growth for most of the species of South Dakota's forests continues to increase. Growth expressed as a percent of volume is presented for the 10 most abundant species (by cubic foot volume) in South Dakota in 2010 (Fig. 28). Most of the economically desirable tree species, such as ponderosa pine, bur oak, cottonwood, and green ash, continue to accrue yearly growth. However, insects, disease, and fires, are impacting net growth for some species. In the extreme example of quaking aspen, disease-caused mortality is resulting in a negative average annual net growth. Quaking aspen accounts for less than 1 percent of the total net volume of live trees on forest land, but it makes up more than 5 percent of the total volume lost to mortality.

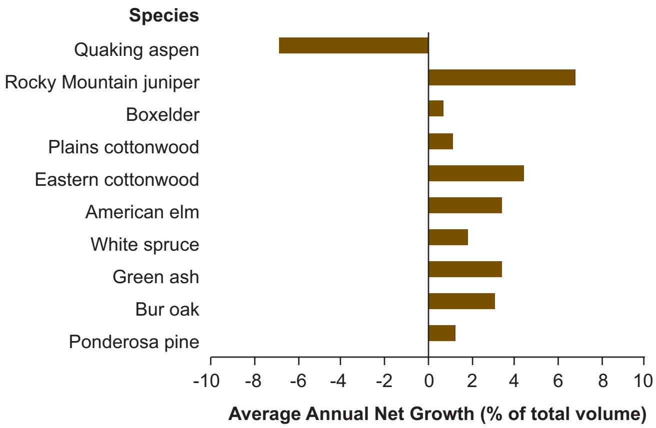


Figure 28.—Average annual net growth of trees on forest land as a percentage of total volume for the10 most abundant species (by volume), in South Dakota, 2010.

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, fire, adverse weather, succession, competition, old age, or human or animal activities, and is often the result of a combination of factors. Tree volume lost as a result of land clearing or harvesting is not included in mortality estimates. Mortality estimates represent the average volume (cubic feet) of sound wood in trees that died each year as an average for the years between inventories, 2005 and 2010.

What we found

Average annual mortality of trees on forest land is an estimated 29.8 million cubic feet per year. More than 40 percent of the gross growth of live trees on forest land is being lost due to mortality. Between 2005 and 2010, the average annual mortality of growing-stock trees on timberland was 22.8 million cubic feet. National Forests accounted for 60 percent of the average annual mortality on forest land, and 65 percent of the annual net mortality on timberland (Fig. 29). The Cheyenne RBA accounted for about half of the mortality volume on both forest land and timberland, and the Belle Fourche-Grand-Moreau RBA accounted for about a quarter of the mortality (by volume) on forest land and timberland (Fig. 30).

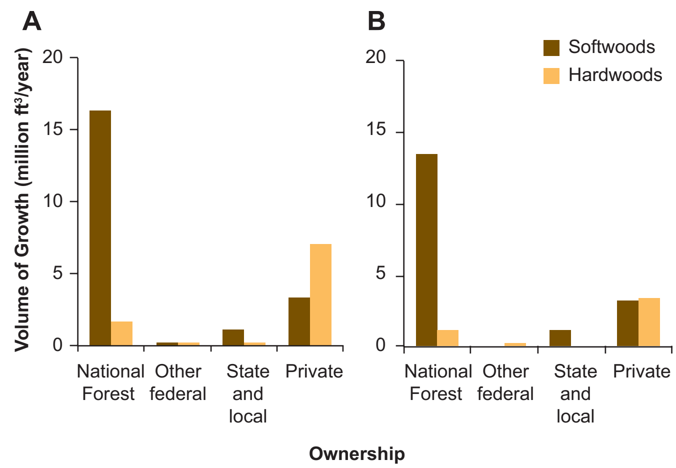


Figure 29.—Average annual mortality of live trees on forest land (A) and average annual mortality of growing-stock trees on timberland (B) by ownership group and softwoods and hardwoods, South Dakota, 2010.

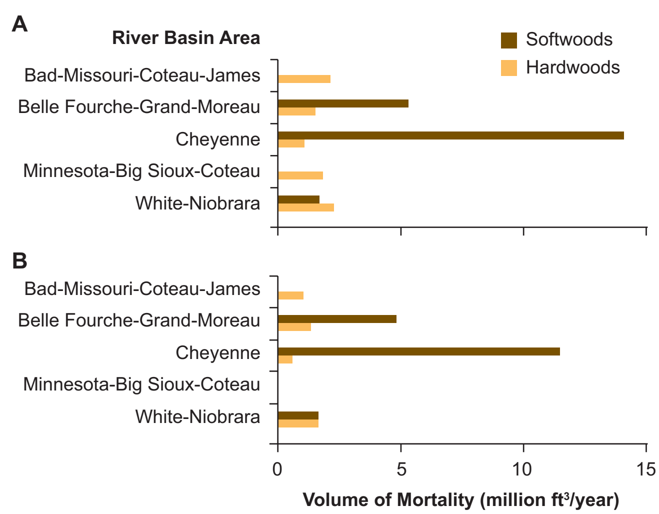


Figure 30.—Average annual mortality of trees on forest land (A) and average annual mortality of growing-stock trees on timberland (B) by river basin area and softwoods and hardwoods, South Dakota, 2010.

What this means

While mortality is a natural process as forest stands mature and change over time, very high rates of mortality could indicate a serious forest health issue or a substantial decline due to aging or other factor(s). Ponderosa pine continues to experience high mortality levels due to mountain pine beetle, weather, and fires (Fig. 31). Quaking aspen and American elm have the second and third highest levels of mortality, mostly due to disease. Insects are responsible for more than a third of the total mortality in South Dakota, followed by extreme weather (20 percent), and fires (15 percent).

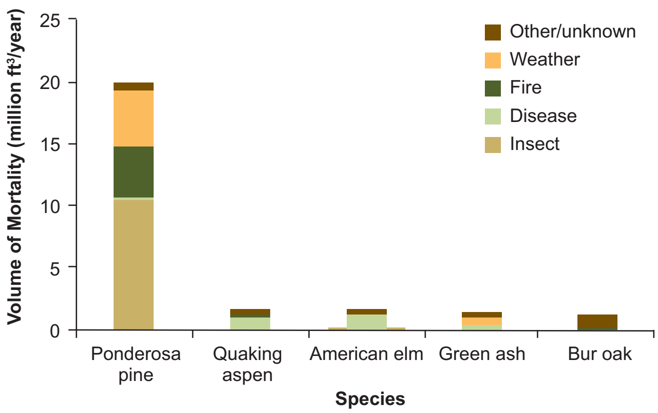


Figure 31.—Average annual mortality of trees (at least 5 inches d.b.h./d.r.c.) on forest land by cause of death for select species, South Dakota, 2010.

Tree Removals

Background

There are three types of removals: harvest removals, mortality removals (trees killed during harvesting or thinning processes and left on the land), and diversion removals (living trees previously on land classified as forest land now on land classified as nonforest land). Changes in the quantity or volume removed help to identify trends in land use change and forest management. Because removals are generally recorded on a limited number of plots, the estimates for removals show greater variance than those for growth, mortality, or area. As with forest growth and mortality, the rate at which trees are removed represents the average annual removals that occurred between 2005 and 2010.

What we found

Average annual removals of live trees on forest land is an estimated 26.5 million cubic feet per year (3.3 million cubic feet less than losses from live tree mortality on forest land), and the average annual removals of growing-stock trees on timberland is an estimated 25.5 million cubic feet per year (2.7 million cubic feet more than losses from growing-stock tree mortality on timberland) (Fig. 32). More than 95 percent of the average annual removals of live trees on forest land and the average annual removals of growing-stock trees on timberland are softwoods. The Cheyenne RBA accounts for 65 percent of the removals volume on both forest land and timberland, and the Belle Fourche-Grand-Moreau RBA accounts for another 30 percent on both forest land and timberland (Fig. 33).

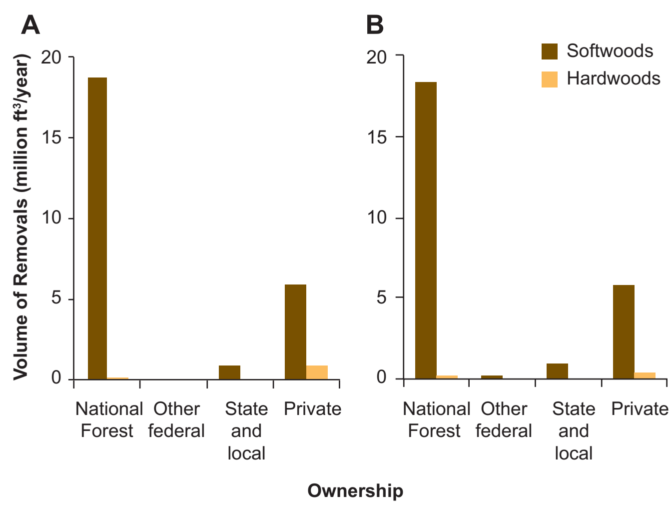


Figure 32.—Average annual removals of trees on forest land (A) and average annual removals of growing-stock trees on timberland (B) by ownership group and softwoods and hardwoods, South Dakota, 2010.

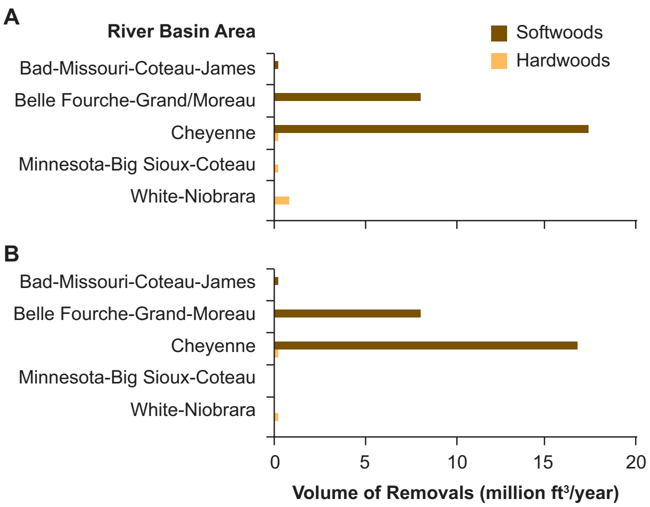


Figure 33.—Average annual removals of trees on forest land (A) and average annual removals of growing-stock trees on timberland (B) by river basin area and softwoods and hardwoods, South Dakota, 2010.

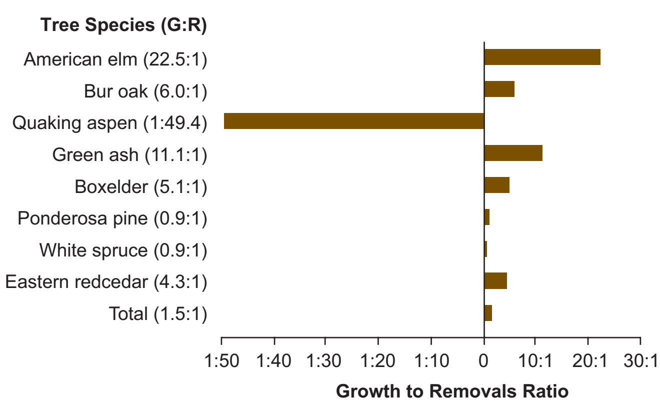


Figure 34.—Growth to removal ratio of trees on forest land by species, South Dakota, 2010.

One measure of sustainability is the ratio of average annual net growth (gross growth minus mortality) to average annual removals (G:R). A G:R of 1:1 means that for every 1 cubic foot of net growth, there is 1 cubic foot of removals. In most cases, it is desirable to have the net growth number be greater than the removals number, which means that net volume is increasing. But in some cases, it may be desirable for removals to be greater than net growth for a short period of time, as in the case of thinning overstocked stands. The overall G:R for South Dakota is 1.5:1 which indicates that, overall, average annual net growth exceeds average annual removals (Fig. 34). This is not true for all species though. For softwoods, the G:R ratio for white spruce and ponderosa pine is just under 1:1. This is mostly due to the high mortality rates from insects, and from harvesting to thin out over-stocked stands. For hardwoods, the extremely high mortality rate for quaking aspen results in a negative average annual growth rate. So, even though only 0.1 percent of the live volume is being removed each year, the G:R ratio is actually negative. For all other species that were found to have removals, the G:R ratio is greater than 4:1.

What this means

Removal rates are indicative of both harvest and land use change. Nearly 100 percent of the removals for South Dakota in 2010 where the result of harvesting. Only about 1 percent of the current volume of live trees is being removed annually. When mortality caused by the mountain pine beetle decreases, the G:R ratio for ponderosa pine should begin to improve. In addition, a decrease in fire caused mortality will have a positive effect on the G:R ratio for all species.

Forest Health

James River riparian forests. Photo by Gregory Josten, South Dakota Department of Agriculture, Resource Conservation and Forestry Division, used with permission.

Tree Crowns

Background

The condition of tree crowns is an indicator of general tree health. Vigorous tree growth is associated with full, dense crowns (Schomaker 2003). Small, sparse crowns suggest poor growth conditions resulting from disturbances such as disease, insect activity, and harsh weather events, or from unfavorable site conditions such as nutrient deficiency, overcrowding, or moisture stress. Three components of crown condition are monitored on live trees by FIA: crown density, crown dieback, and sapling crown vigor. Crown density is an estimate of crown fullness and represents the amount of foliage, branches, and reproductive structures that block light through the crown (U.S. Forest Service 2007). Dieback is a measure of twig and branch mortality within the crown. Sapling vigor is an estimate of the crown condition and health of saplings based on estimates of crown ratio, dieback, and condition of foliage (U.S. Forest Service 2007).

What we found

The frequency distribution of crown dieback in South Dakota's tree crowns is dominated by the 0 and 1 to 5 percent classes (Fig. 35). This represents a very low level of crown dieback. From the 2005 inventory to the 2010 inventory, there is an increase of occurrences in the 1 to 5 percent class and a decrease in the 0 percent class. The remaining dieback classes are relatively stable.

Most tree crown densities are at the 31 to 50 percent levels, indicating a decline from the 2005 inventory where most fell into the 41 to 60 percent level (Fig. 36). Crown density of 30 percent or more is considered healthy and an indicator of good tree vigor. Sapling crown vigor has improved from the previous inventory, with all of the saplings in the good or fair categories and an increase in the percentage of saplings in the good category (Fig. 37).

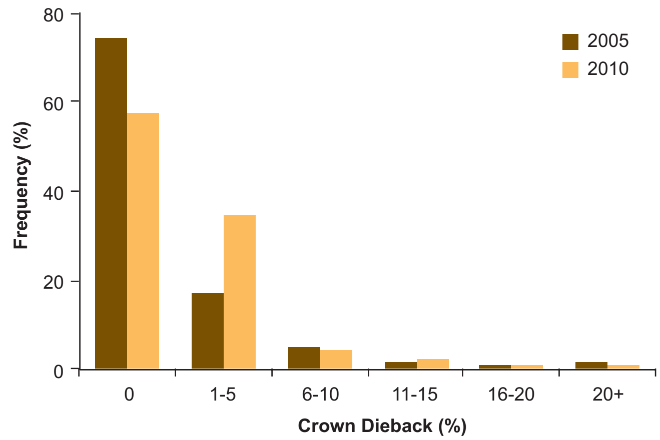


Figure 35.—Crown dieback classes and frequency distribution, South Dakota, 2005 and 2010.

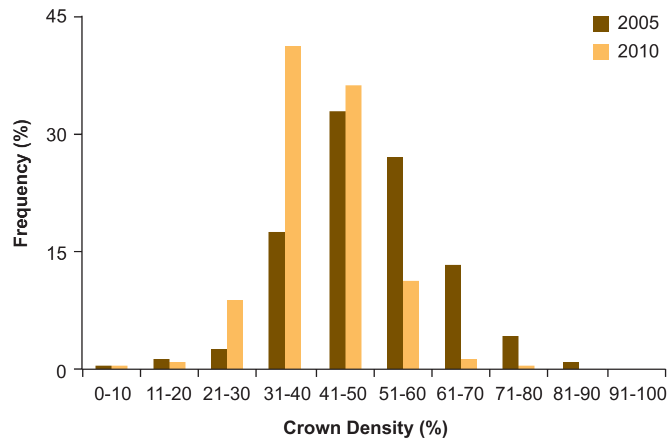


Figure 36.—Crown density classes and frequency distribution, South Dakota, 2005 and 2010.

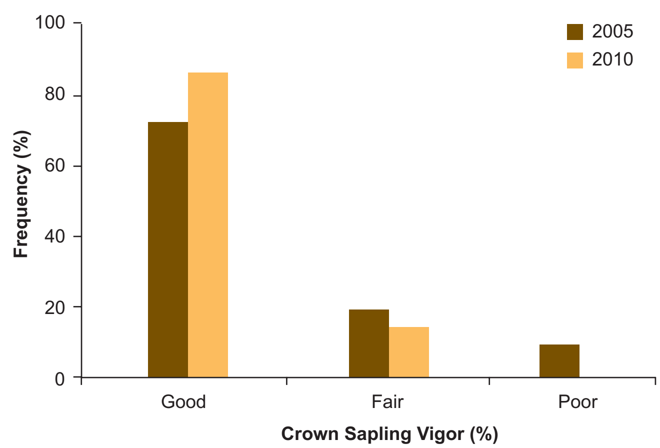


Figure 37.—Crown sapling vigor classes and frequency distribution, South Dakota, 2005 and 2010.

What this means

Live tree crowns across South Dakota appear to be healthy, although crown densities are shifting toward being less dense and more trees show small amounts of crown dieback. Because the condition of tree crowns is often the first indicator of impending forest health issues, the conclusion may be made that while individual tree health is good, the slight changes in tree crown health in the negative direction warrant continued monitoring to see if this trend continues.

Given the relatively sparse number of tree crown samples (tree crown health is measured on Phase 3 forest health plots only), it is difficult to make statewide conclusions on individual species or species groups. Therefore, it is impossible for a direct analysis of the conditions of ponderosa pine, which is impacted by a major mountain pine beetle epidemic. Because of this epidemic, one might expect the crown densities to be lower and the dieback higher than the data indicates given that a large ponderosa pine component comprises South Dakota's forests. Due to the limitation of crown condition data being collected on live trees only and the short time period between mountain pine beetle infestation and mortality, there are few live ponderosa pine trees that are sampled after infestation but prior to death.

Down Woody Materials

Background

Down woody materials, including fallen trees and branches, fill a critical ecological niche in South Dakota's forests. They provide valuable wildlife habitat in the form of coarse woody debris, and contribute to forest fire hazards via surface woody fuels, and 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 South Dakota's forests are relatively low, especially when compared with Minnesota (Fig. 38). The size distribution of coarse woody debris (diameter larger than 3 inches) is overwhelmingly dominated (71 percent) by pieces less than 8 inches in diameter (Fig. 39A). Moderately decayed coarse woody pieces (decay classes 2, 3, and 4) constitute 89 percent of the decay class distribution (Fig. 39B). The carbon stocks of coarse woody debris appear to be stable (approximately 2 tons/acre) across stocking classes on South Dakota's forest land except in minimally-stocked stands (basal area between 30.1 and 60.0 ft^2) where carbon stocks are approximately 0.25 tons/acre (Fig. 40).

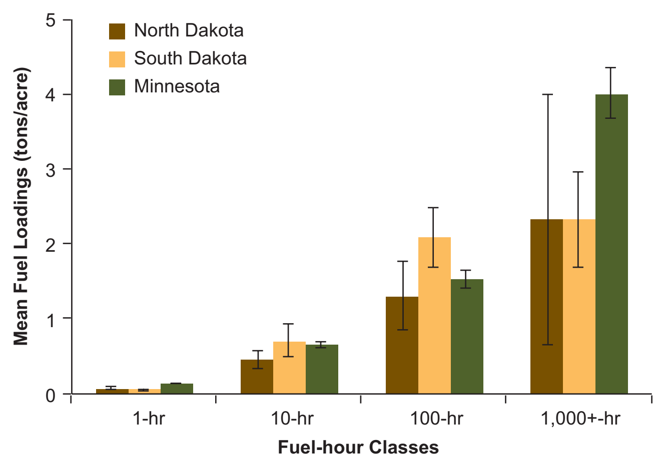


Figure 38.—Means of fuel on forest land in South Dakota and neighboring states, 2010. Error bars show the 68 percent confidence interval around the estimate.

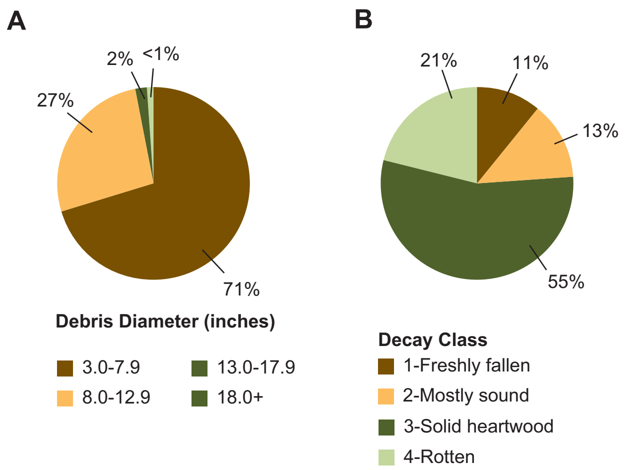


Figure 39.—Proportions of coarse woody debris by size class (A) and decay class (B) on forest land, South Dakota, 2010.

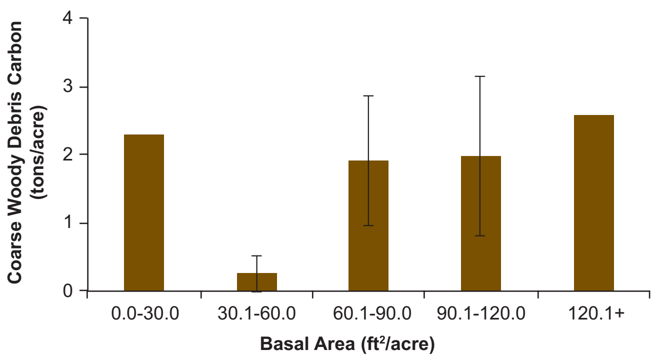


Figure 40.—Distribution of coarse woody debris carbon by forest land basal area, South Dakota, 2010. Error bars show the 68 percent confidence interval around the estimate.

What this means

The fuel loadings of downed 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 exceeds any negative forest health aspects. The population of coarse woody debris across South Dakota consists mostly of small pieces that are moderately decayed. Due to this, coarse woody debris constitutes a small, albeit important carbon stock across South Dakota's forests. Compared to nearby states, the population of down woody materials in South Dakota's forests appears stable while providing valuable ecosystem services.

Ozone Damage

Background

Ozone is a naturally occurring component of the atmosphere. Beneficial when found in the upper atmosphere, ozone is considered an air pollutant when found in the lower atmosphere. Ozone is mainly produced in metropolitan areas by automobile exhaust and industrial processes but polluted air masses can be transported hundreds of miles downwind of population centers elevating ozone levels in rural areas (Smith et al. 2008). 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

Ozone bioindicator data has been collected in South Dakota beginning in 2002. There are 12 biosites where ozone-sensitive plants are evaluated for injury every year (Table 5). More than 11,000 plants have been evaluated since 2002. Only 1 plant in 2007 shows any symptoms of ozone damage, with those symptoms being a very low-level of damage. The most common ozone-sensitive bioindicator species that are evaluated in South Dakota include snowberry, common and tall milkweed, western wormwood, white ash, spreading dogbane, and ponderosa pine.

Table 5.—Number of biosites and plants evaluated for ozone injury, South Dakota, 2002-2010.

	Survey year								
	2002	2003	2004	2005	2006	2007	2008	2009	2010
Number of biosites	12	12	12	12	12	12	12	12	12
Number of plants evaluated	753	1,264	1,170	1,406	1,432	1,340	1,278	1,273	1,142
Number of plants with injury	0	0	0	0	0	1	0	0	0
Average number of species/biosite	3.25	3.92	4.17	3.75	3.92	4.50	4.17	4.42	3.75

What this means

South Dakota's forests are exposed to very low levels of ground-level ozone pollution. The level of exposure is generally not sufficient to result in observable or measurable adverse impacts. Consequently, the risk from ozone exposure is considered low throughout the State.

Forest Insects and Disease

Background

South Dakota's forests sustained damage from a range of native and nonnative insects and pathogens in the period from 2006 to 2010. Insects and pathogens often cause damage when forests are affected by abiotic stressors such as drought and storm damage. Many of the native pests are recurring and cyclic while playing an integral role in the ecology of South Dakota forests. However, nonnative pests and native pests that reach prolonged outbreak epidemics are having serious negative impacts on forests and trees. Monitoring forest damage and surveying for insects and pathogens are crucial to predicting and managing South Dakota's future forest resources.

What we found

The most persistent and devastating damaging agent in the State, the mountain pine beetle, is discussed in a later section.

Bark beetles from the *Ips* genus, the most common in South Dakota being the pine engraver beetle (*Ips pini*), have been actively causing damage. These native beetles usually attack trees that are stressed or injured by abiotic means, such as drought, ice and snow storms, and fire. Tree mortality estimates caused by the pine engraver beetle have decreased significantly from a high period in the early 2000s (Fig. 41). A complex known as sudden aspen decline (SAD) is causing damage and mortality in stands of trembling aspen across the Rocky Mountains, especially in Colorado. Sudden aspen decline is characterized by rapid branch dieback, crown thinning, and mortality without the involvement of primary pathogens and insects (Worrall et al. 2010). This complex has not affected much of the aspen population in South Dakota, although it has been recorded as occurring in the State by aerial detection surveys (Fig. 42). Other insects and pathogens causing damage in South Dakota are listed in Table 6. White pine blister rust is present in the only existing stand of limber pines

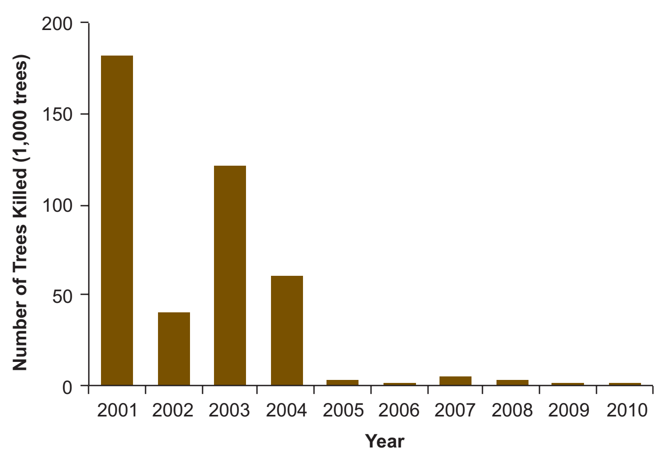


Figure 41.—Number of trees killed by pine engraver beetle, South Dakota, 2001–2010.

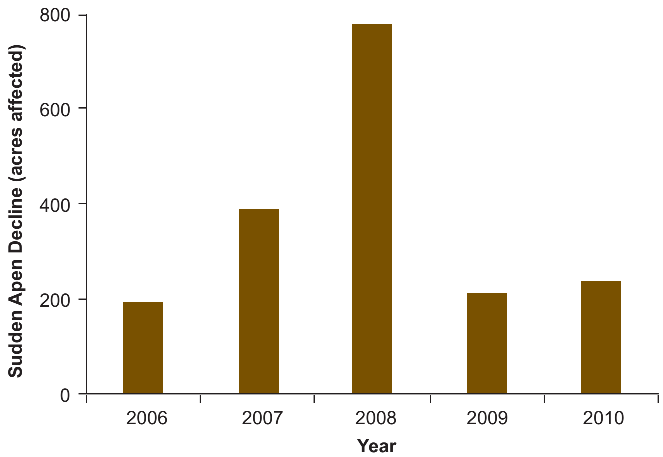


Figure 42.—Acres of forest damaged by sudden aspen decline, South Dakota, 2006–2010.

left in the State, however, many treatments have been done in an attempt to save the stand. The banded elm bark beetle is found throughout the State wherever elms are found. The population is causing Siberian elms to decline in western South Dakota communities and may be increasing American elm mortality as the beetle serves as a vector for Dutch elm disease.

What this means

Insects and pathogens cause damage and losses throughout forests and communities in South Dakota every year. Some of the impacts are local or regional and confined to a year or two, while others are statewide and ongoing. When combined with trees stressed by drought, flood, fire, or weather events, insects and pathogens can have a devastating effect on forest, community, and windbreak trees. Monitoring continues through the annual aerial detection survey performed by the Forest Service and through on-the-ground efforts, such as detection trapping. Future concerns for South Dakota include the health of the ponderosa pine forests of the Black Hills and new invasive insects and pathogens.

Table 6.—Other insects and pathogens affecting South Dakota forests, 2006–2010.

Damaging agent	Host(s)
Insects–Native	
Flatheaded wood borer	
Two-lined chestnut borer *(Agrilus bilineatus)*	Bur oak
Bronze birch borer *(Agrilus anxius)*	Birch
Hackberry borer *(Agrilus celti)*	Hackberry
Redheaded ash borer *(Neoclytus acuminatus)*	Ash
Spruce needleminer *(Endothenia albolineana)*	Spruce
Web-spinning sawflies *(Neurotoma fasciata)*	Cherry, plum
Zimmerman pine moth *(Dioryctria* spp.)	Austrian, ponderosa, and Scotch pines, and Colorado blue spruce
Insects–Nonnative	
Banded elm bark beetle *(Scolytus schevyrewi)*	Elm
Gypsy moth *(Lymantria dispar)*	Hardwoods
Pathogens–Native	
Armillaria root disease *(Armillariella* spp.)	Softwoods and Hardwoods
Pine wilt nematode *(Bursaphelenchus xylophilus)*	Austrian and Scotch pines
Western gall rust *(Endocronartium harknessii)*	Ponderosa pine
Pathogens–Nonnative	
Dutch elm disease *(Ophiostoma ulmi* and *Ophiostoma novo-ulmi)*	America elm
White pine blister rust *(Cronartium ribicola)*	Limber pine
Diplodia blight (*Sphaeropsis sapineaor* (*Diplodia pinea*))	Austrian, ponderosa, and Scotch pines

Mountain Pine Beetle

Background

The mountain pine beetle (*Dendroctonus ponderosae*) (MPB) is a bark beetle native to western North America with a range from northern Mexico to British Columbia, Canada. MPB can inhabit and reproduce in all species of pine within their range, but the primary host species are lodgepole, ponderosa, western white, sugar, limber, and whitebark pines. Tree death results from girdling due to gallery construction by the beetle and blockage of water-conducting cells by the growth of blue stain fungi, spores of which are carried by MPB (Gibson et al. 2009). During times of low population levels, MPB infest stressed trees causing scattered mortality at low levels. Widespread tree mortality can occur when populations reach outbreak levels, especially when conditions are favorable to prolonged outbreaks over many years, e.g., mild winters, multi-year droughts, and dense stands. The western United States is currently experiencing a MPB outbreak of epidemic proportions, with millions of trees killed over hundreds of thousands of acres of forest land. The pine forests of South Dakota have seen a MPB outbreak since the mid-1990s.

What we found

With an estimated 331 million trees, ponderosa pine is the most numerous species on South Dakota's forest lands. Ponderosa pine is found in western South Dakota, mainly in the Black Hills region. The ponderosa pine forest type occurs on 60 percent of the forest land in South Dakota or 1.13 million acres. The Forest Service conducts annual aerial detection surveys to assess areas damaged by insects and disease, including MPB. It is estimated that varying levels of MPB activity have affected 369,000 acres of forest land between 1996 and 2010 (Harris 2011). Areas of damage in the Black Hills region are mainly located in the central and northern portion of the hills (Fig. 43).

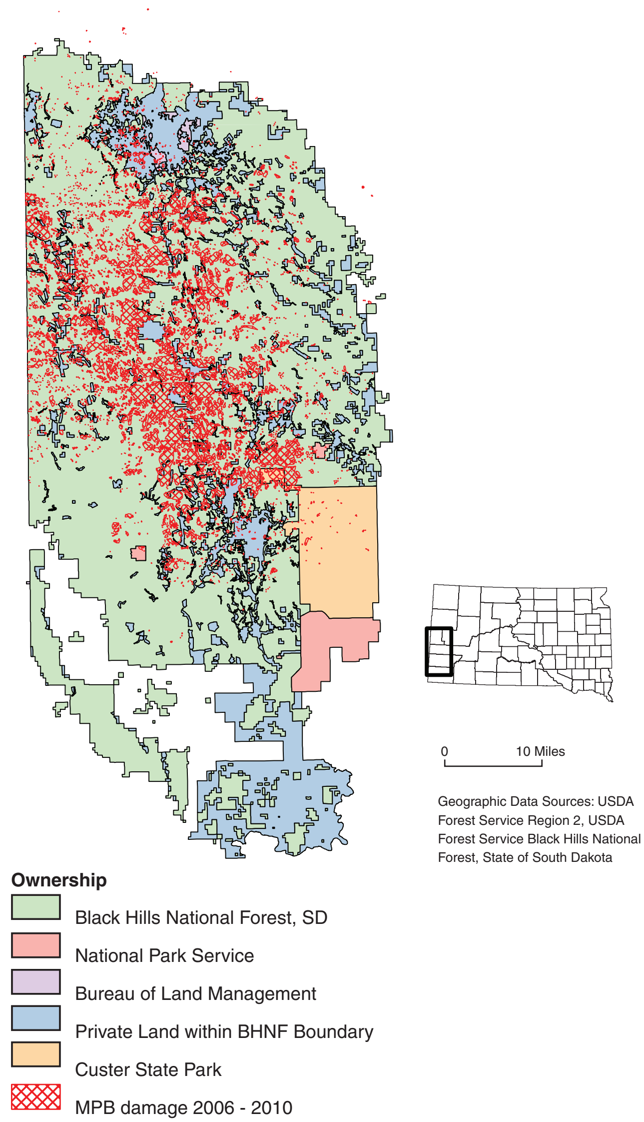


Figure 43.—Areas identified with mountain pine beetle damage in the Black Hills, by ownership, South Dakota, 2006–2010.

What this means

Because ponderosa pine is such a large component of South Dakota's forest resource, the ongoing MPB epidemic continues to be a significant problem. Mitigation efforts are under way by the state of South Dakota and the Black Hills National Forest to slow the spread of MPB, but the outbreak remains at epidemic levels. Without treatment, the beetle spreads and causes an increase in standing dead ponderosa pine trees and down woody material, which in turn, increases fire hazards.

Emerald Ash Borer

Background

The emerald ash borer (*Agrilus planipennis*) (EAB), a wood-boring beetle native to Asia, was first detected in the United States in southeastern Michigan in 2002 (Poland and McCullough 2006). In North America, EAB has been identified as a pest of only ash species, with at least 16 native ash species appearing to be susceptible (Cappaert et al. 2005, McCullough and Siegert 2007). Trees and branches as small as 1 inch 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 South Dakota during the 2010 inventory, but the threat of its introduction has increased with the discovery of EAB in Minnesota and Iowa. To prepare for the potential arrival of EAB and other invasive pests, a regional survey of urban and nonforest land was conducted by state forestry agencies in South Dakota, North Dakota, Nebraska, and Kansas, in conjunction with the U.S. Forest Service's National Inventory and Monitoring Applications Center (NIMAC). This regional survey effort is part of the Great Plains Tree and Forest Invasives Initiative (GPI), which gives state forestry agencies the opportunity to work together to create public awareness, promote alternatives to ash tree plantings, and assess the region's tree resources as a means to determine and address the potential impacts of EAB to those resources.

What we found

Green ash is a dominant species on South Dakota forest land. With an estimated 21.5 million trees (greater than 1inch diameter) that account for 82.9 million cubic feet of live volume, green ash is the fifth most abundant species by number and ranks third by volume (Fig. 44). Ash is distributed across much of South Dakota, however, the most ash is concentrated in the south-central, southwestern, and northeastern portions of the State (Fig. 45). Present on approximately 228,000 acres, or 12 percent of forest land, green ash generally makes up less than 25 percent of total live-tree basal area (Fig. 46). The GPI inventory shows that nonforest land, including windbreaks, shelterbelts, and wooded riparian strips, contains 28 million ash trees, while an additional 1 million ash trees are present in urban areas.

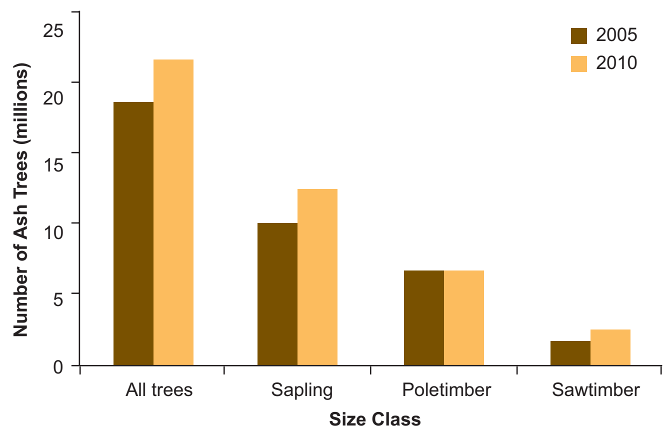


Figure 44.—Number of ash trees on forest land by inventory year and size class, South Dakota, 2005 and 2010.

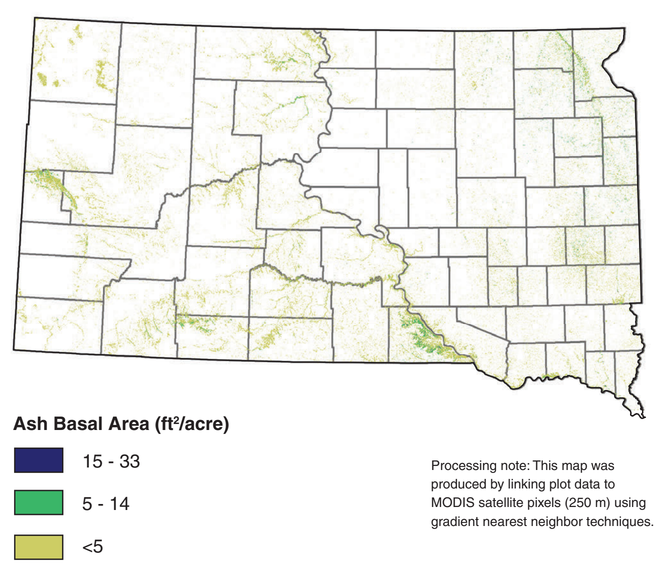


Figure 45.—Ash basal area on forest land in South Dakota, 2010.

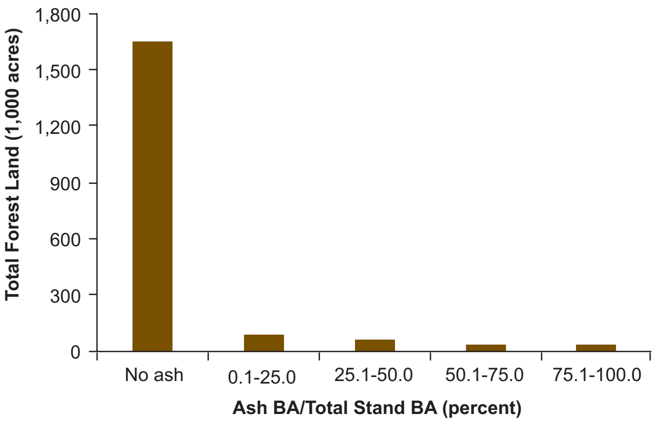


Figure 46.—Presence of ash on forest land, expressed as a percentage ash basal area to stand basal area (BA), South Dakota, 2010.

What this means

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

Understory Vegetation and Species Diversity

Background

The diversity of plant life is an important component in most terrestrial forest ecosystems. Because plants are able to convert the sun's energy into food 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 or group of species to survive (e.g., certain 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 South Dakota, vegetation data have been collected on approximately 6.25 percent of P3 field plots since 2007, resulting in a complete vegetation survey on 18 plots. Since South Dakota has a low number of P3 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

South Dakota's forests support many plant species. Six hundred seventy-one identifiable species were found on P3 plots from 2007 through 2010. Of the species recorded, the largest percentage was classified as forb/herbs (44 percent) (Fig. 47), based on the Natural Resources Conservation Service's PLANTS Database (NRCS 2012). Graminoids also comprised a significant proportion—19 percent—of the species observed on P3 plots. Of the species recorded, 80 percent were native to the United States, 10 percent were introduced, 5 percent were classified as native and introduced species, and 5 percent were unclassified (Fig. 48).

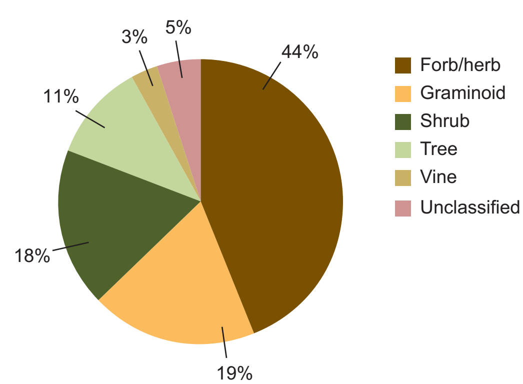


Figure 47.—Percentage of species on P3 plots by growth habit category (NRCS 2012), South Dakota, 2007-2010.

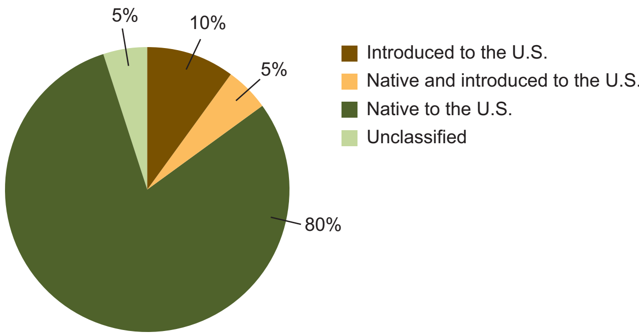


Figure 48.—Percentage of species found on P3 plots by origin (NRCS 2012), South Dakota, 2007-2010.

On P3 plots, the number of species and genera range from 2 to 63 per plot, with an average of 39 (Fig. 49). The 17 most frequently encountered species are listed in Table 7, with ponderosa pine being the most common, found on 12 plots. Two species (common dandelion and Kentucky bluegrass) listed are not native but are classified as "native and introduced", meaning some cultivars and varieties are native while others are introduced (NRCS 2012).

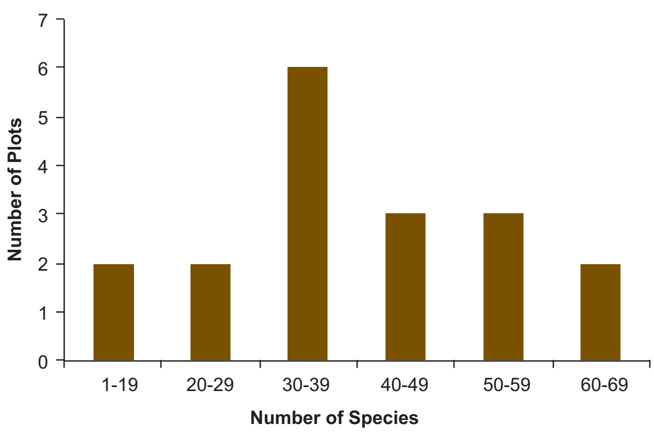


Figure 49.—Number of species observed per P3 plot, South Dakota, 2007-2010.

Table 7.—The 17 most common plant species on South Dakota Phase 3 plots listed by the number of observances and the percentage of plots the species occurred, 2007-2010.

Species	Number of observances	Percentage of plots
Ponderosa pine	12	66.7
Common dandelion	10	55.6
Kentucky bluegrass	10	55.6
White sagebrush	10	55.6
Chokecherry	8	44.4
Common juniper	8	44.4
Blue grama	7	38.9
Green ash	7	38.9
Prairie junegrass	7	38.9
Threadleaf sedge	7	38.9
Western wheatgrass	7	38.9
American vetch	6	33.3
Fragrant sumac	6	33.3
Kinnikinnick	6	33.3
Sideoats grama	6	33.3
Small-leaf pussytoes	6	33.3
Wild bergamot	6	33.3

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 is comprised of those species that have been introduced (Table 8). Forbs/herbs dominate the list. The most frequently observed nonnative plant species were common dandelion and Kentucky bluegrass, which were each observed on 10 plots.

South Dakota's forests support 312 species, while neighboring North Dakota supports only 116 (Haugen et al. 2013). However, comparing plant diversity across states must be done with caution due to differing sample sizes. South Dakota had 4.5 times more plots inventoried than North Dakota.

Table 8.—The 15 most common nonnative plant species on South Dakota Phase 3 plots listed by the number of observances and the percentage of plots the species occurred, 2007-2010.

Species	Number of observances	Percentage of plots
Common dandelion	10	55.6
Kentucky bluegrass	10	55.6
Red clover	5	27.8
Canada bluegrass	4	22.2
Common yarrow	4	22.2
Field brome	4	22.2
Narrowleaf plantain	4	22.2
Smooth brome	4	22.2
Yellow salsify	4	22.2
Black medick	3	16.7
Canada thistle	3	16.7
Catnip	3	16.7
Prickly lettuce	3	16.7
Stinging nettle	3	16.7
Timothy	3	16.7

What this means

Both native and nonnative species were found on the P3 plots in South Dakota. The presence of nonnative and invasive plants within the forest community is potentially problematic as they can displace the native plants upon which fauna depend. The invasive plants are a particular concern since 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 enhance our understanding of how forest communities change and the factors that influence the presence of various species.

Nonnative Invasive Plants

Background

Invasive plants (IP) have the potential to supplant native species and change plant communities. They are often very aggressive colonizers that readily establish from vegetative propagules (e.g., multiflora rose) and often produce copious amounts of seed (e.g., garlic mustard). Not only are IP a concern within the forest, they can also cause agricultural damage through reduced crop yield. Invasive plants are alternate hosts for harmful insects and diseases such as common buckthorn and the soybean aphid (Heimpel et al. 2010), and common barberry and wheat stem rust (Roelfs 1982). After establishing in an area, some IP, such as black locust, can change the soil chemistry by altering nutrient availability (von Holle et al. 2006), which can displace native species and support their spread. IP have spread throughout the United States, costing billions of dollars for inspection, monitoring, and eradication. From 2007 through 2010, NRS-FIA collected invasive species data on 61 forested Phase 2 Invasive plots in South Dakota (approximately 20 percent of the P2 field plots).

What we found

Table 9 shows the list of IP that NRS-FIA monitors. Data from South Dakota's P2 invasive plots suggest that IP are present throughout the State. Of the 43 species monitored, seven were present (Table 10). Bull and Canada thistle are present on the greatest number of plots—seven. All other IP found were observed on one plot. Of these species, all were present at 2.0 percent cover or less (calculated for each invasive species observed on P2 invasive plots by summing the average plot coverage for each plot the species was found and then dividing by the total number of plots the species occurred), except for Siberian elm, which had a cover of 12.5 percent. The coverage data should be interpreted with caution due to the low number of observances.

Table 9.—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)*

Table 10.—Invasive plant species observed on South Dakota Phase 2 invasive plots, 2007-2010.

Common name	Number of observances	Percentage of plots	Mean cover
Bull thistle	7	11.5	0.6
Canada thistle	7	11.5	2.0
Common buckthorn	1	1.6	0.8
Japanese honeysuckle	1	1.6	0.5
Leafy spurge	1	1.6	0.3
Russian olive	1	1.6	0.0
Siberian elm	1	1.6	12.5

Invasive plant distribution is shown in Figures 50 and 51. The statewide distribution of bull and Canada thistle is shown in Figure 50. Bull thistle was observed mainly on the plots in the south-central and southwestern part of the State; however this region also has the highest number of plots monitored since it is the most forested part of the State. This same trend was found for Canada thistle, though it also occurred on one plot in the southern part of the State. Figure 51 shows plots where field crew observed the IP monitored by NRS-FIA.

South Dakota has 7 invasive plant species detected, the same number as the neighboring state of North Dakota (Haugen et al. 2013), however there were fewer P2 invasive plots in North Dakota. About 31 percent of the P2 invasive plots in South Dakota had IP present in comparison to half of the plots in North Dakota (Haugen et al. 2013).

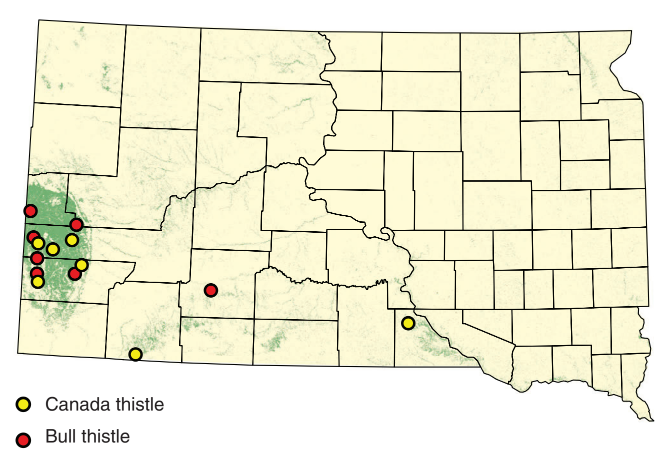


Figure 50.—Distribution of Canada thistle and bull thistle on P2 invasive plots, South Dakota, 2007-2010; plot locations are approximate.

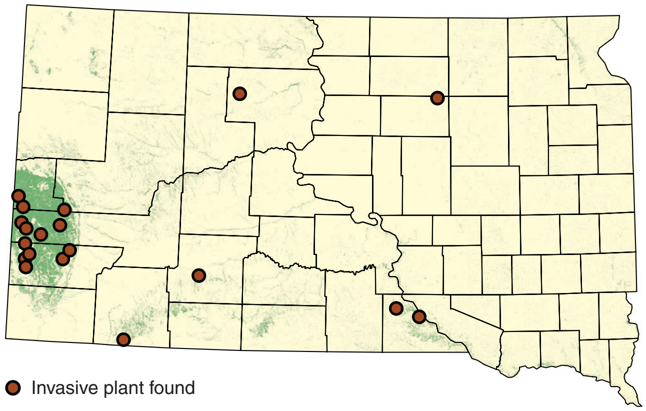


Figure 51.—Distribution of invasive plant species on P2 invasive plots, South Dakota, 2007-2010; plot locations are approximate.

What this means

NRS-FIA data suggest that IP are present in most of South Dakota's large forested ecosystems. These species can alter the forest through reducing forage, displacing native species, reducing biodiversity, and changing nutrient and hydrologic properties. By changing plant communities IP can impact the animal communities that depend on the native plants.

Aside from the potential ecological damage of IP, they can also cause economic impacts through lost revenues that would have been derived from the displaced native species and through the costs of management and remediation. Gathering data on IP helps individuals and land managers understand the abundance and distribution of these species. Monitoring of IP in future inventories will enhance our understanding of how they impact the forest community and allow managers to observe their abundance and spread. Monitoring also will help determine what site characteristics influence the presence of IP, with the goal of creating forested conditions that minimize invasion and the impact of these forest invaders.

Forest Products

Black Hills National Forest. Photo by Gregory Josten, South Dakota Department of Agriculture, Resource Conservation and Forestry Division, used with permission.

Growing-stock Volume

Background

Growing-stock volume is a measure that has been used to estimate the volume of wood material that is available for the manufacturing of timber products. Growing-stock volume is the volume of merchantable wood in standing live trees that is sound, reasonably straight, and more than 5 inches d.b.h. Knowing the growing-stock volume that is available for producing wood products is important in economic planning and development and is an essential consideration in evaluating sustainable forest management.

What we found

After increasing between 1996 and 2005, the 2010 growing-stock volume remains at the 2005 level of 1.9 million cubic feet (Fig. 52). The 2 percent increase of softwood volume was offset by the 15 percent decrease of hardwood volume. White spruce was the only softwood species that had a decrease of growing-stock volume between 2005 and 2010. For hardwoods, only 2 of the top 5 species had an increase in the volume of growing stock (cottonwood and American elm). Green ash, bur oak, and quaking aspen growing-stock volumes all decreased between 2005 and 2010. Only the Cheyenne RBA had an increase (2 percent) in growing-stock volume from 2005 to 2010. Growing-stock volume decreased by almost 20 percent in the Bad-Missouri-Coteau-James RBA, and by 2 percent in both the Belle Fourche-Grand-Moreau and the Minnesota-Big Sioux-Cotea RBAs, and it remained at the 2005 level in the White-Niobrara RBA (Fig. 53).

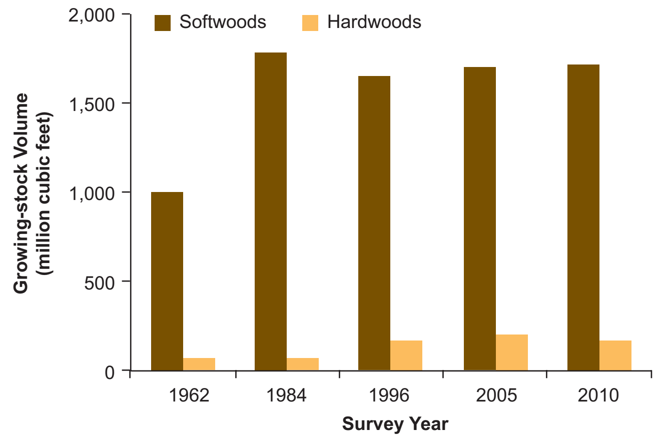


Figure 52.—Growing-stock volume on timberland by hardwoods and softwoods, and survey year, South Dakota.

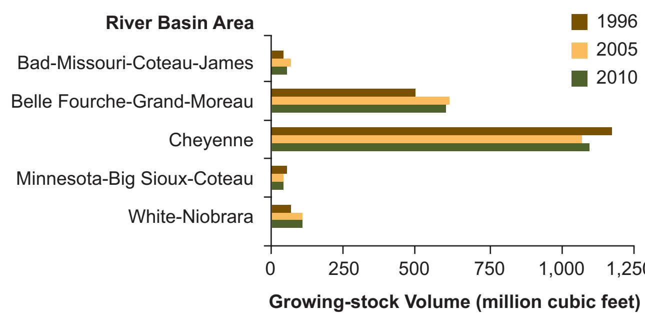


Figure 53.—Growing-stock volume on timberland by river basin area, South Dakota, 1996, 2005, and 2010.

What this means

White spruce, bur oak, green ash, and quaking aspen reported a loss in the volume of growing stock between 2005 and 2010. These are important species for wildlife, urban areas, and forest products. Many forest stands in South Dakota are in the large diameter class. As trees reach maturity, their growth slows and they may actually begin to loose volume due to rot and decay as they become overmature. Quaking aspen, which is considered a short-lived species, is an example of this. Quaking aspen mortality by volume is exceeding growth, so stands are losing volume. For a number of critical tree species the primary volume gains are found in larger tree diameters. Sustainability issues (e.g., regeneration) of mature forest stands containing economically vital tree species should be monitored into the future.

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 at least 9 inches d.b.h. to qualify as sawtimber. Sawtimber volume is defined as the net volume of the saw log portion of live sawtimber, measured in board feet, from a 1-foot stump to minimum top diameter (9 inches for hardwoods and 7 inches for softwoods). Estimates of sawtimber volume, expressed as board feet International ¼-inch rule (with board feet Scribner rule in parenthesis), are used to determine the monetary value of wood volume and to identify the quantity of merchantable wood availabile.

What we found

After decreasing by 7 percent between 1996 and 2005, the volume of sawtimber increased from 6.6 million board feet (5.7 million board feet Scribner rule) in 2005 to 6.9 million board feet (5.9 million board feet Scribner rule) in 2010, a 5 percent increase (Fig. 54). Softwood sawtimber volume increased by 5 percent while hardwood sawtimber decreased by 3 percent. Between 2005 and 2010, the volume of sawtimber on timberland increased by 8 percent in the Cheyenne RBA, by 4 percent in the Minnesota-Big Sioux-Coteau RBA, and by 3 percent in the Belle Fourche-Grand-Moreau RBA. Sawtimber volume decreased by 10 percent in the Bad-Missouri-Coteau-James RBA and by 9 percent in the White-Niobrara RBA (Fig. 55).

All species had a positive average annual net growth of sawtimber on timberland in South Dakota in 2011 (Fig. 56). Average annual mortality of sawtimber on timberland was nearly 90 percent of the total annual gross growth for quaking aspen and bur oak. High average annual removals of sawtimber for white spruce and eastern redcedar, along with the high mortality rate for white spruce, resulted in these two species having the

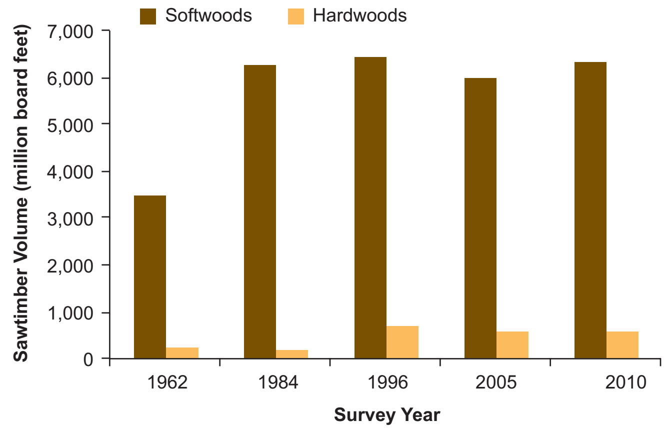


Figure 54.—Sawtimber volume (International ¼ inch rule) on timberland by hardwoods and softwoods, and survey year, South Dakota.

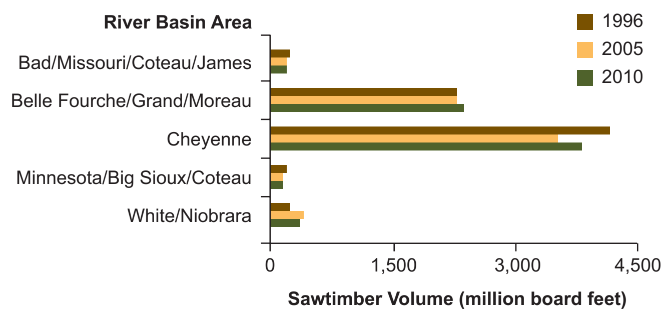


Figure 55.—Sawtimber volume (International ¼ inch rule) on timberland by river basin area, South Dakota, 1996, 2005, and 2010.

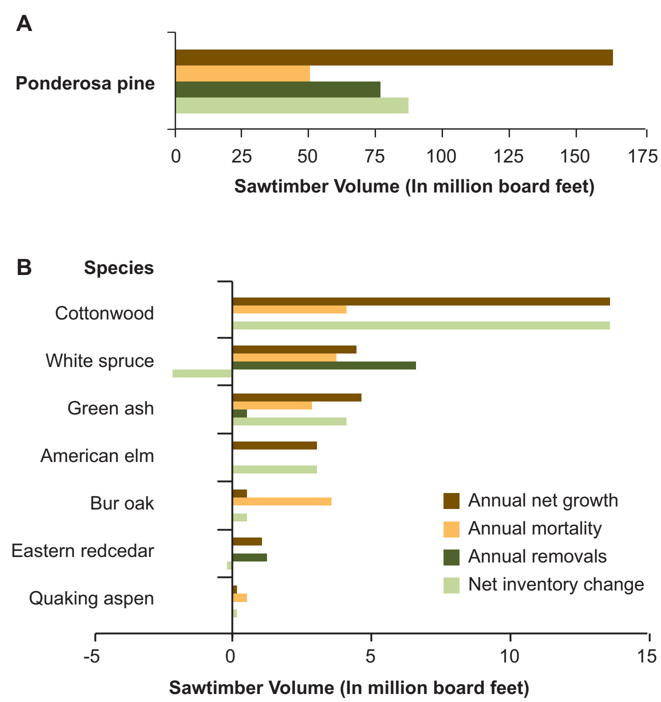


Figure 56.—Average annual net growth, mortality, removals, and net change of sawtimber (volume; International ¼ inch rule) on timberland for ponderosa pine (A) and other select species (B), South Dakota, 2010.

only negative net inventory change (average annual net growth minus average annual removals).

Even though sawtimber volume increased by 5 percent between 2005 and 2010, the average volume of sawtimber per acre of timberland decreased by 8 percent. The average sawtimber volume per acre of timberland decreased by more than 20 percent in the Minnesota-Big Sioux-Coteau RBA, and by more than 30 percent in the White-Niobrara and Bad-Missouri-Coteau-James RBAs. The decreases in these areas can be primarily attributed to the increased area of timberland in these regions. The area of timberland in each of these three RBAs increased by more than 30 percent between 2005 and 2010. More than 25 percent of the total timberland area in these three RBAs was not classified as timberland in 2005.

What this means

Land that has converted from nontimberland to timberland due to landowner actions, such as the decision to stop grazing an area, may be more susceptible to reverting back to nontimberland. For example, if a landowner's decision to stop grazing his livestock in a wood lot was based on economic reasons, a change in the economy may prompt the landowner to begin grazing his livestock in that wood lot again. This conversion back and forth in land use classes will also result in an increase and decreases in growing-stock and sawtimber volume over time.

A Comparison of Volume Models for Ponderosa Pine

Background

A tree's volume can be precisely determined by immersing it in a pool of water and measuring the amount of water displaced. As such a process is typically cost prohibitive for forest inventories, models of tree volume based on tree metrics (e.g., tree diameter) must be used to estimate volume. Often, there are a variety of tree volume models for common tree species. For ponderosa pine in South Dakota, FIA-NRS used tree volume equations based on Myers (1964).

Other tree volume equations have been developed for ponderosa pine in South Dakota, most notably, the Flewelling profile model (Flewelling and Raynes 1993) and the Czaplewski profile model (Czaplewski 1989). The Myers volume equations rely on species, d.b.h, and height to calculate tree net volume (from 1 foot stump to 4 inch top), whereas the Flewelling and Czaplewski profile models also require the height to the merchantable top (4 inches). To compare the Myers tree volume equations to those of Flewelling and Czaplewski, MS Excel volume functions were installed from the National Volume Estimator Library (NVEL) (http://www.fs.fed.us/fmsc/measure/volume/nvel/index.php). The NVEL Excel volume functions allow tree volumes to be calculated using different volume equations.

What we found

The net volume of live ponderosa pine trees 5 inches or greater on forest land in South Dakota exceeds 1.7 billion cubic feet using the Myers tree volume equations (Fig. 57). The NVEL Excel volume functions produced an estimate of 1.8 billion cubic feet using the Czaplewski profile model (a difference of 6 percent) and 1.6 billion cubic feet using the Flewelling profile model (a difference of -9 percent).

What this means

When looking at the estimated tree volumes derived from a variety of models, it is important to assess differences across a range of diameters. For ponderosa pine in South Dakota, the Czaplewski profile model appears to provide larger estimates of small-diameter tree volume and smaller estimates of large-diameter tree volume compared to the Myers volume equation. On the other hand, when compared with the Myers volume equation, the Flewelling profile model had

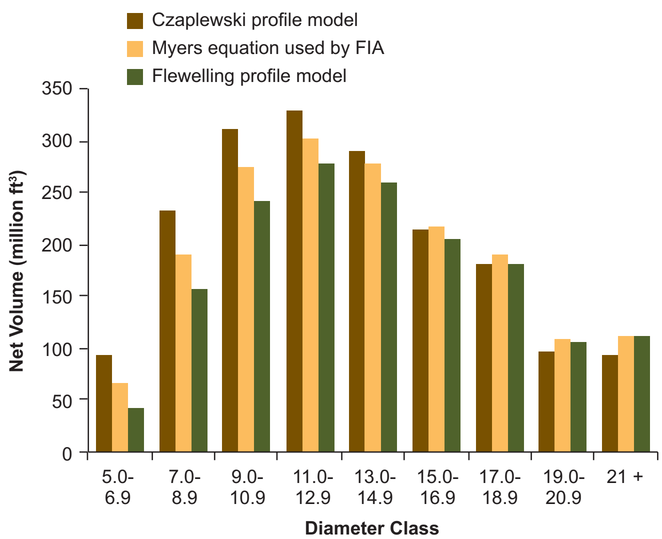


Figure 57.—Net volume of live ponderosa pine (at least 5 inches d.b.h.), on forest land by diameter class and volume equation model, South Dakota, 2010.

smaller estimates of small-diameter tree volume, but as the trees diameter became larger, the difference between the two was reduced. The difference between the total net volume of ponderosa pine trees 21 inches or greater using Myers volume equations and the Flewelling profile model was less than 0.5 percent.

Carbon stocks

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 South Dakota. Instead, a combination of empirically derived carbon estimates (e.g., standing live trees) and models (e.g., carbon in soil organic matter is based on stand age and forest type) are used to estimate South Dakota's forest carbon. Estimation procedures are detailed by Smith et al. (2006).

What we found

South Dakota forests contain more than 93 million tons of carbon. Soil organic matter (SOM) represents the largest forest ecosystem carbon stock in the State at more than 47 million tons, followed by live trees and saplings at more than 27 million tons (Fig. 58). Within the live tree and sapling pool, merchantable boles contain the bulk of the carbon (~ 17 million tons) followed by roots (~ 5 million tons) and tops and limbs (~ 3 million tons). Most of South Dakota's forest carbon stocks are found in moderately aged stands, 61-100+ years old (Fig. 59). Early in stand development most of the forest ecosystem carbon is in the SOM and belowground tree components. As forest stands mature, the ratio of above to belowground carbon shifts and by the 100+ age class the aboveground components represent the majority of ecosystem carbon. This trend continues well into stand development as carbon accumulates in live and dead aboveground components. A look at carbon by forest-type group on a per-unit-area basis found that 9 of the 12 groups have between 45-65 tons of carbon per acre (Fig. 60). Despite the similarity in per-acre estimates, the distribution of forest carbon stocks by forest-type group is quite variable. For example, the pinyon/juniper group has 31 percent (~ 15 tons per acre) of the forest carbon in the litter layer, whereas the elm/ash/cottonwood group has only 6 percent (~ 4 tons per acre) in the litter material.

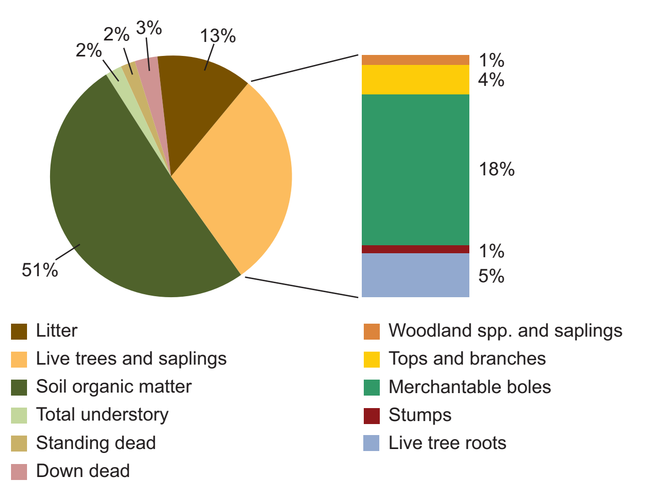


Figure 58.—Estimated carbon stocks on forest land by forest ecosystem component, South Dakota, 2010.

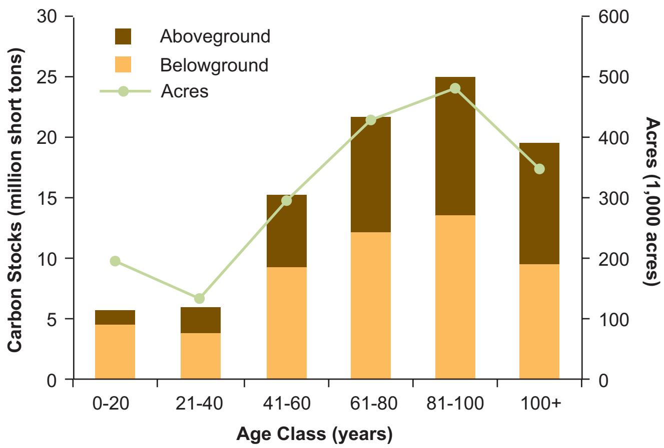


Figure 59.—Estimated aboveground and belowground carbon stocks on forest land by stand age class, South Dakota, 2010.

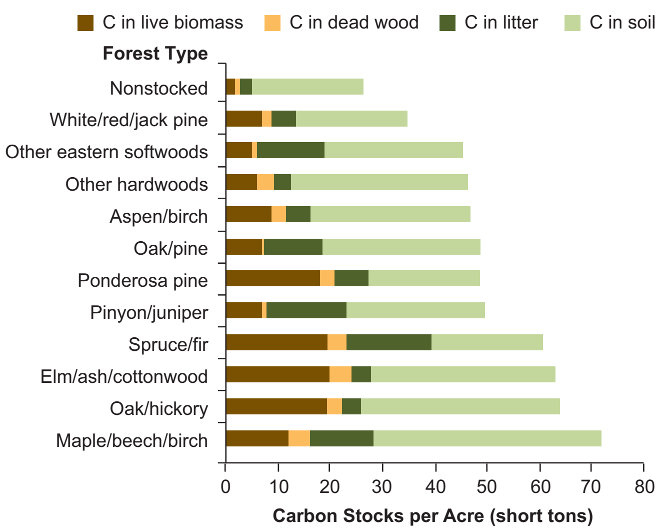


Figure 60.—Estimated carbon per acre on forest land by forest-type group and carbon pool, South Dakota, 2010. Note that the other hardwoods group includes exotic hardwoods and other hardwood forest types.

What this means

Carbon stocks in South Dakota's forests have increased substantially over the last several decades. Most forest carbon in the State is found in moderately aged stands dominated by relatively long-lived species. This suggests that South Dakota's forest carbon will continue to increase as stands mature and accumulate carbon in above- and belowground components. Given the age class structure and species composition of forests in South 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.

Timber Product Output

Background

Surveys of South Dakota's wood-processing mills are conducted periodically to estimate the amount of wood that is processed into products. The most recent survey was conducted in 2009. This information is supplemented with the most recent surveys conducted in surrounding states that processed wood harvested from South Dakota.

The harvesting and processing of timber products produces a stream of income shared by timber owner, managers, marketers, loggers, truckers, and processors. In 2007, the wood products and paper manufacturing industries (NAICS codes 321 and 322) in South Dakota employed 2,470 people, with an average annual payroll of $86.1 million and total value of shipments of $560.9 million (U.S. Census Bur. 2007.) To better manage the State's forests, it is important to know the species, amounts, and locations of timber being harvested.

What we found

There were 23 active primary wood processing mills in 2009 that processed 26.0 million cubic feet of industrial roundwood into lumber, particleboard, posts, and other wood products (Piva and Josten in press).

In 2009, 24.7 million cubic feet of industrial roundwood was harvested from South Dakota's forest land. Saw logs accounted for 84 percent of the industrial roundwood that was harvested in South Dakota (Fig. 61). Other products harvested were posts, pulpwood, cabin logs, excelsior/shavings, and other miscellaneous products. Ponderosa pine accounted for 98 percent of the industrial roundwood harvested (Fig. 62). White spruce and cottonwood were the next most harvested species.

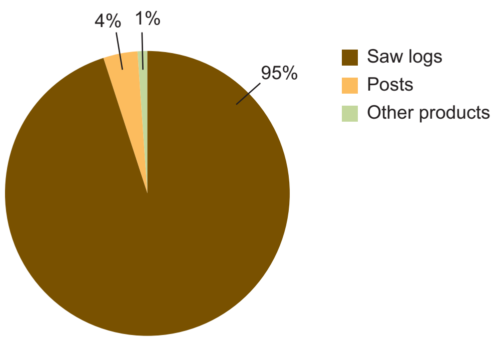


Figure 61.—Industrial roundwood products harvested, South Dakota, 2009.

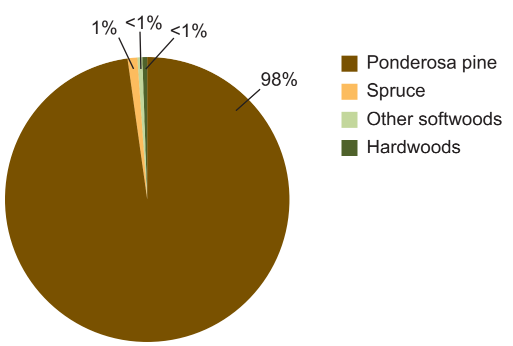


Figure 62.—Industrial roundwood production by species or species group, South Dakota, 2009.

In the process of harvesting industrial roundwood, 10.4 million cubic feet of harvest residues were left on the ground (Fig. 63). More than 80 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 372,000 green tons of wood and bark residues. Nearly 40 percent of the mill residues were used for fiber products such as pulp and particleboard. Another 20 percent of the mill residues were used for industrial fuelwood, and 19 percent were used to make wood pellets. Only 1 percent of the mill residues were not used for other products (Fig. 64).

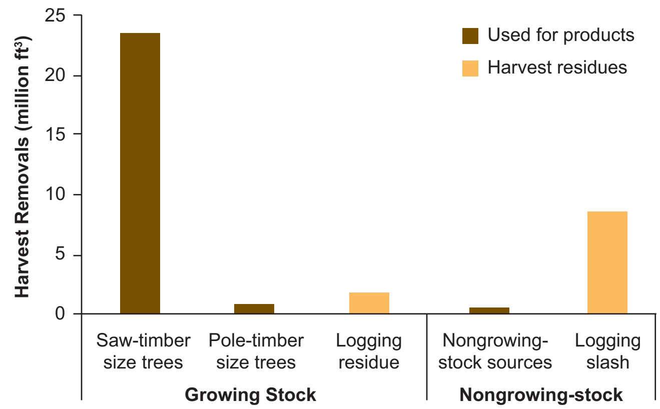


Figure 63.—Harvest removals from industrial roundwood by growing stock and nongrowing Stock, and end use, South Dakota, 2009.

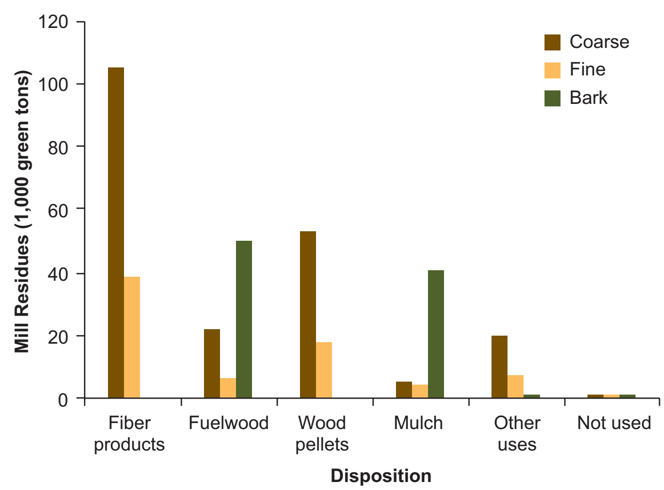


Figure 64.—Disposition of mill residues, by residue type, South Dakota, 2009.

What this means

Nearly all of the wood-processing facilities in South Dakota are sawmills in the Black Hills and along the east-central border of the State. These mills provide woodland owners with an outlet to sell timber and provide jobs in some of the State's rural areas. The demand for wood products is likely to increase as the population increases. Currently, the hardwood resource throughout most of the State is being used only lightly. Since the resource is scattered, portable sawmills that can process trees on-site would allow for better utilization of the forest resource. Harvesting older stands that may be on the verge of decline due to age will open up the forest to regeneration and better growth on the remaining trees. The use of harvest residues for cogeneration or biofuels facilities has limited potential for the Black Hills and east-central border of the State.

Forest Habitats

Forests and woodlands provide habitats for South Dakota birds (143 species), mammals (63 species), and amphibians and reptiles (28 species) (NatureServe 2011). Broadly speaking, forest habitats include Black Hills conifer forest, flood plain and upland forest, farm woodlots, shelterbelts, and urban tree cover. Black Hills forest species include bobcat (*Felis rufus*), elk (*Cervus elaphus*), mountain lion (*Felis concolor*), American marten (*Martes americana*), common porcupine (*Erethizon dorsatum*), canyon wren (*Catherpes mexicanus*), least chipmunk (*Tamias minimus*), brook trout (*Salvelinus fontinalis*), rainbow trout (*Oncorhynchus mykiss*), and brown trout (*Salmo trutta*). Wildlife species typical of flood plain and upland forests include wild turkey (*Meleagris gallopavo*), wood duck (*Aix sponsa*), bald eagle (*Haliaeetus leucocephalus*), beaver (*Castor canadensis*), songbirds, herons, deer, fox, turtles, and frogs.

Like all states, South Dakota has developed a State Wildlife Action Plan (SWAP) based upon guidance provided by U.S. Congress, the U.S. Fish and Wildlife Service, and the International Association of Fish and Wildlife Agencies. Produced by South Dakota Game, Fish, & Parks, the "South Dakota Wildlife Action Plan" (South Dakota Department of Game, Fish and Parks 2006) (formerly known as the South Dakota Comprehensive Wildlife Conservation Plan) addresses habitats for 28 bird species, 10 mammal species and 12 amphibian and reptile species of greatest conservation need in the State, several of which are associated with forested ecosystems: northern goshawk (*Accipiter gentilis*), Lewis' woodpecker (*Melanerpes lewis*), fringe-tailed myotis (*Myotis thysanodes pahasapensis*), northern flying squirrel (*Glaucomys sabrinus*), and Black Hills redbelly snake (*Storeris occipitomaculata pahasapae*).

Different forest types at different structural stages provide habitats at a "coarse filter" scale of conservation. Rare, imperiled, or wide-ranging wildlife species may not be fully served at this scale, so a "fine filter" approach is used to identify species-specific conservation needs. Representing an intermediate or "meso-filter" scale of conservation are specific habitat features (e.g., snags, riparian forest strips), which may serve particular habitat requirements for multiple species. This report characterizes South Dakota's forest and woodland habitats in terms of forest age and size classes (coarse-filter scale) and standing dead trees (meso-filter scale).

The trend of increasing forest land area is generally interpreted as a positive conservation outcome, but encroachment of woody invasive species into historically nonforest habitats may have negative effects on prairie and grassland dependent wildlife. Managing for both forest and nonforest habitats across a variety of compositional and structural conditions will promote healthy wildlife populations in South Dakota.

Forest Age and Size

Background

Some species of wildlife depend on early successional forests comprised of smaller, younger trees, while others require older, interior forests containing large trees with complex canopy structure. Yet other species inhabit the ecotone (edge) between different forest stages, and many require multiple structural stages of forests to meet different phases of their life history needs. For example, northern goshawks in the Black Hills nest in trees of larger diameter (averaging 16.5 in. d.b.h.) than surrounding trees. Diameter, height, stage of decay, and canopy cover determine the suitability of trees as bat roost sites. Abundance and trends in these structural and successional stages serve as indicators of population carrying capacity for wildlife species (Hunter et al. 2001). Historical trends in South Dakota's forest habitats are reported for timberland, which comprises more than 96 percent of all forest land in the State. For current habitat conditions, estimates are reported for all forest land.

What we found

Abundance of large-diameter stand-size class has increased steadily in South Dakota since 1995 and now comprises about two-thirds of all forest land, while small- and medium-diameter stand-size classes have shown more variable patterns (Fig. 65). Timberland area under 20 years of age has decreased since 1995. Most other age classes of timberland have seen increasing abundance, with exception of the oldest age classes, which are stable or slightly decreasing in abundance. Forty-five percent of South Dakota's timberland is older than 80 years and 18 percent is older than 100 years. Abundance of these older age classes has been fairly stable in recent times (Fig. 66). A small fraction of South Dakota's timberland exceeds 200 years of age, but too few plots occur within this age class to produce reliable estimates. A fairly even distribution of age classes occurs within the small-diameter stand-size class. The medium-diameter stand-size class is dominated by forest of 21-80 years of age. Stand ages of 41-150 years predominate in the large-diameter stand-size class, and forest younger than 40 years exceeds forest older than 150 years in this size class (Fig. 67).

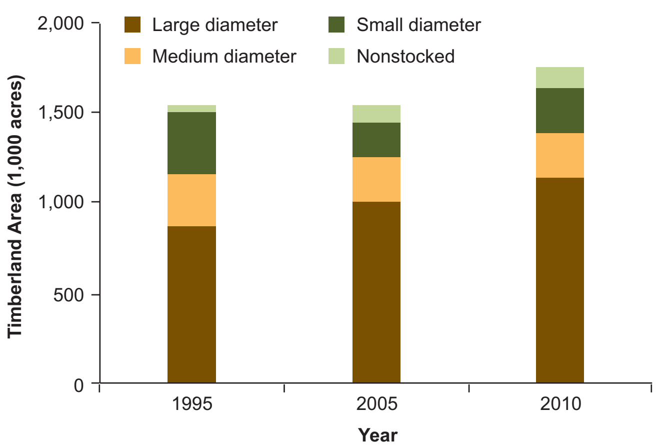


Figure 65.—Area of timberland by stand-size class, South Dakota, 1995, 2005, and 2010.

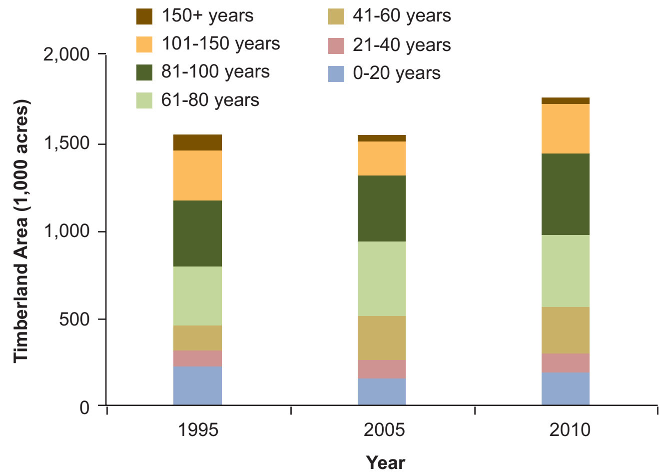


Figure 66.—Area of timberland by stand-age class, South Dakota, 1995, 2005, and 2010.

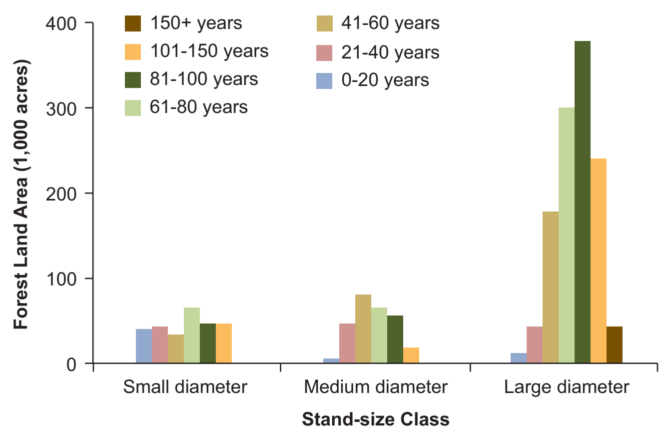


Figure 67.—Area of forest land by age class and stand-size class, South Dakota, 2010.

What this means

South Dakota's forests are dominated by larger, older trees, typical of ponderosa pine forests of the Black Hills. It is interesting to see the presence of some small-diameter forest in older stand ages and the occurrence of large-diameter forest in younger stand ages. These combinations can occur when a few huge trees and numerous smaller trees occur in the same vicinity, although rare coding anomalies also may result in unexpected combinations. Mixtures of different ages and sizes of trees provide a vertical diversity of vegetation structure that can enhance habitat conditions for wildlife species. Diverse structural conditions appear to benefit pine marten—a species reintroduced to the Black Hills in the 1980s—especially when prey species and denning cavities also are present.

Outside of Black Hills forests, which comprise about two-thirds of South Dakota's forest lands, forest habitats are primarily restricted to farm woodlots and river woodland corridors, with the Missouri River corridor being prominent. Both woodlots and riparian woodlands provide important stop-over habitat for songbirds during migration. Riparian forests are especially important for several of South Dakota's bat species, where large cottonwood trees are preferred as roosts. There is a need to maintain forest conditions in both early- and late-successional habitats to provide smaller and larger structural stages for a variety of forest-associated species.

Standing Dead Trees (Snags)

Background

Specific features like nesting cavities and standing dead trees provide critical habitat components for many forest-associated wildlife species. Standing dead trees that are large enough to meet habitat requirements for wildlife are referred to as snags. According to one definition, "…for wildlife habitat purposes, a snag is sometimes regarded as being at least 10 in (25.4 cm) in diameter at breast height [d.b.h.] and at least 6 ft (1.8 m) tall" (Helms 1998). All three woodpeckers among South Dakota's species of greatest conservation need (SGCN) utilize standing dead trees for nest cavities. Black-backed and three-toed woodpeckers also use areas with standing dead trees where they feed primarily on the larvae of wood-boring beetles. In contrast, Lewis's woodpecker rarely excavates for wood-boring insects; rather this species catches insects by gleaning and flycatching in open ponderosa pine forest or open riparian woodlands. Another SGCN, the northern flying squirrel, is a secondary cavity nester, occupying nest cavities previously excavated by woodpeckers or other primary cavity nesters. Standing dead trees serve as important indicators not only of wildlife habitat, but also for past mortality events and carbon storage. And, they serve as sources of down woody material (discussed elsewhere in this report), which also provides habitat features for wildlife such as the Black Hills redbelly snake. The number and density of standing dead trees, together with decay classes, species, and sizes, define an important wildlife habitat feature across South Dakota's forests.

FIA collects data on standing dead trees (at least 5 inches d.b.h./d.r.c.) of numerous species and sizes in varying stages of decay.

What we found

More than 28 million standing dead trees are present on South Dakota forest land. This equates to an overall density of 15.0 standing dead trees per acre of forest land, with slightly higher densities on public (16.9) than on private (11.9) forest land. Compared to current density of standing dead trees density was similar (14.6) during the 2001-2005 inventory, but lower during the 1995 inventory (9.5). Four tree species each contributed more than 1 million standing dead trees, with ponderosa pine exceeding 18 million, (Fig. 68). Nine species exceeded 10 standing dead trees per 100 live trees (of at least 5 inch d.b.h./d.r.c.), with plains cottonwood topping the list at more than 70 standing dead trees per 100 live trees (Fig. 69). Eighty percent of standing dead trees were smaller than 11 inches d.b.h./d.r.c., with one-third being smaller than 7 inches d.b.h./d.r.c. (Fig. 70). More than 83 percent of standing dead trees showed decay within three intermediate classes, a pattern which was consistent across most diameter classes (Fig. 70).

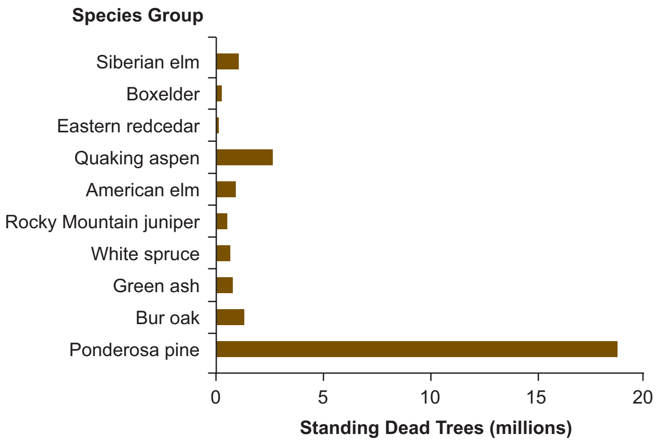


Figure 68.—Number of standing dead trees at least 5 inches d.b.h./d.r.c. on forest land by species, South Dakota, 2010.

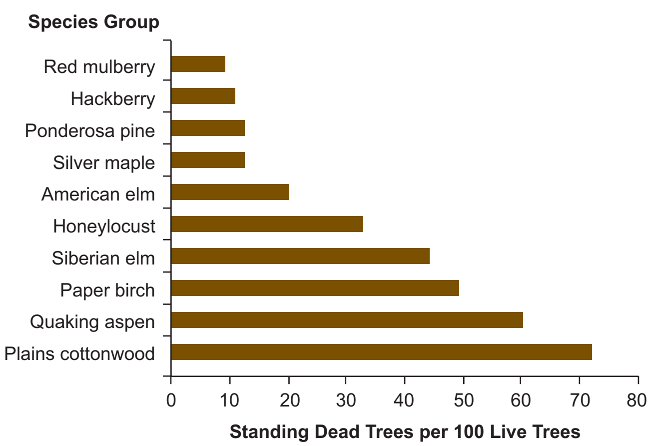


Figure 69.—Number of standing dead trees at least 5 inches d.b.h. per 100 live trees at least 5 inches d.b.h. on forest land by species, South Dakota, 2010.

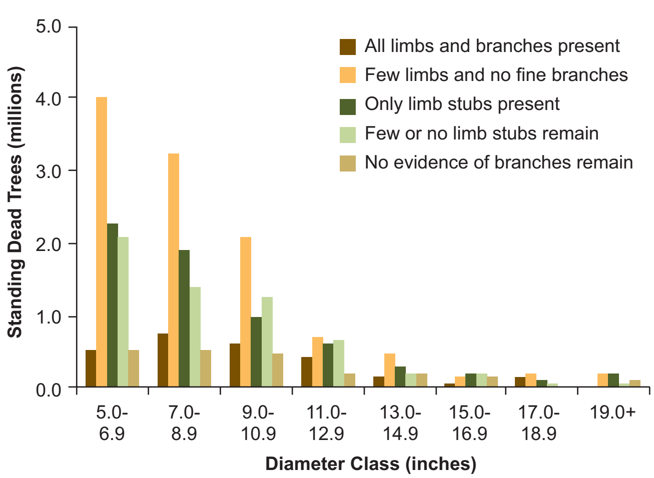


Figure 70.—Distribution of standing dead trees at least 5 inches d.b.h./d.r.c. on forest land by decay and diameter classes for all dead trees in South Dakota, 2010.

What this means

Snags and smaller standing dead trees result from a variety of potential causes, including diseases and insects, weather damage, fire, flooding, drought, and competition, and other factors. Other softwood species groups contained the largest total number of standing dead trees, predominately ponderosa pine, but cottonwood and aspen species groups had the highest density of standing dead trees on South Dakota's forest land. Compared to the number of live trees, the number of standing dead trees is relatively small, but they typically contain significantly more nest cavities per tree than occur in live trees (Fan et al. 2003). Standing dead trees 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. South Dakota's list of SGCN includes both primary and secondary cavity nesters that rely upon standing dead trees for habitat. Most cavity nesting birds are insectivores which help to control insect populations. The availability of very large snags may be a limiting habitat feature for some species of wildlife. Providing a variety of forest structural stages and retaining specific features like snags on both private and public lands are ways that forest managers maintain the abundance and quality of habitat for forest-associated wildlife species in South Dakota.

Data Sources and Techniques

Burr oaks in Newton Hills State Park. Photo by Gregory Josten, South Dakota Department of Agriculture, Resource Conservation and Forestry Division, used with permission.

Forest Inventory

Information on the condition and status of forests in South Dakota was obtained from the Northern Research Station's Forest Inventory and Analysis program. Previous inventories of South Dakota's forest resources were completed in 1935 (Ware 1936), 1962 (all lands west of the 103rd meridian was surveyed in 1960 (Chase 1967) and east of the 103rd meridian was surveyed in 1964 (Choate and Spencer 1969)), 1984 (all lands east of the 103rd meridian was surveyed in 1979 (Collins and Green 1988) and west of the 103rd meridian was surveyed in 1983 (Raile 1984)), 1996 (the area outside the Black Hills National Forest was surveyed in 1996 (Leatherberry et al. 2000) and the Black Hills National Forest was surveyed in 1999 (DeBlander 2002)), and 2005 (Piva et al. 2009). All lands west of the 103rd Meridian were surveyed in 1971 to 1974 (Green 1978), but land to the east of the 103rd Meridian was not surveyed. Therefore, no trend information is given for this time period. In addition to this statewide report for the 2005-2010 South Dakota inventory, a report for the Black Hills National Forest (includes the area of Black Hills National Forest lands in South Dakota and Wyoming) is also being reported for the 2005-2010 inventory (Walters et al. In press).

Tabular data can be generated at the Forest Inventory and Analysis data center Web page at http://www.fiatools.fs.fed.us /. Additional details can be found in the Statistics, Methods, and Quality Assurance section found on the DVD in the inside back cover pocket of this bulletin.

For additional information about FIA, contact: Program Manager, Forest Inventory and Analysis, Northern Research Station, 1992 Folwell Avenue, St. Paul, MN 55108 or Ray Sowers, State Forester, Division of Resource Conservation & Forestry, Foss Building, 523 E. Capitol Ave., Pierre, SD 57501

National Woodland Landowner 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.

Insects and Diseases

Information about the insects and diseases affecting South Dakota's forests was gathered from the U.S. Forest Service, Rocky Mountain Region, Renewable Resources, Forest Health Management program and the South Dakota Department of Agriculture, Division of Resource Conservation and Forestry (SDRCF). Damage polygons were obtained from Rocky Mountain Region Aerial Survey Data. Additional information on the Rocky Mountain Region, Forest Health Management program, along with links to information and data for the Aerial Survey, can be found at http://www.fs.usda.gov/detail/r2/forest-grasslandhealth/. For more information on the health of South Dakota's forests, contact the SDDA Division of Resource Conservation and Forestry.

Timber Products Inventory

The timber products inventory study was a cooperative effort between the SDRCF and the NRS-FIA. The SDRCF canvassed all primary wood-using mills within the State using mail questionnaires supplied by the NRS-FIA and designed to determine the size and composition of South Dakota's primary wood-using industry, its use of roundwood, and its generation and disposition of wood residues. The SDRCF then contacted nonresponding mills through additional mailings, telephone calls, and personal contacts until all know mills were accounted for. Completed questionnaires were forwarded to NRS-FIA for compilation and analysis.

As part of data processing and analysis, all industrial roundwood volumes reported on the questionnaires were converted to standard units of measure using regional conversion factors. Timber removals by source of material and harvest residues generated during logging were estimated from standard product volumes using factors developed from previous NRS-FIA logging utilization studies. Data on South Dakota's industrial roundwood receipts were added to a regional timber removals database and supplemented with data on out-of-state uses of South Dakota roundwood to provide a complete assessment of South Dakota's timber product output.

Mapping Procedures

Maps in this report were created using four different methods. The first method used 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. An example of a map produced using this methodology is Figure 1. The second used categorical coloring of South Dakota's counties or river basins according to various forest attributes, such as forest land area. These are known as choropleth maps. An example of a choropleth map is Figure. 6. The third procedure used colored dots to represent plot attributes at approximate plot locations. The final method is produced by sketchmapping, a remote sensing technique of observing forest change events from an aircraft and documenting them manually onto a map. Figure 43 is an example of sketchmapping.

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DVD Contents

South Dakota's Forests 2010 (PDF)

South Dakota's Forests 2010: Statistics, Methods, and Quality Assurance (PDF)

South Dakota's Forests 2005 (PDF)

South Dakota Inventory Database (CSV files)

South Dakota Inventory Database (MS Access files)

Field guides that describe inventory procedures (PDF)

Database User Guides (PDF)

South Dakota's Forests 2010 Statistics, Methods, and Quality Assurance

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The second completed annual inventory of South Dakota's forests reports 1.9 million acres of forest land. Softwood forests make up 68 percent of the total forest land area, with the ponderosa pine forest type by itself accounting for 60 percent of the total.

KEY WORDS: annual inventory, forest area, forest health, forest products, South Dakota

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