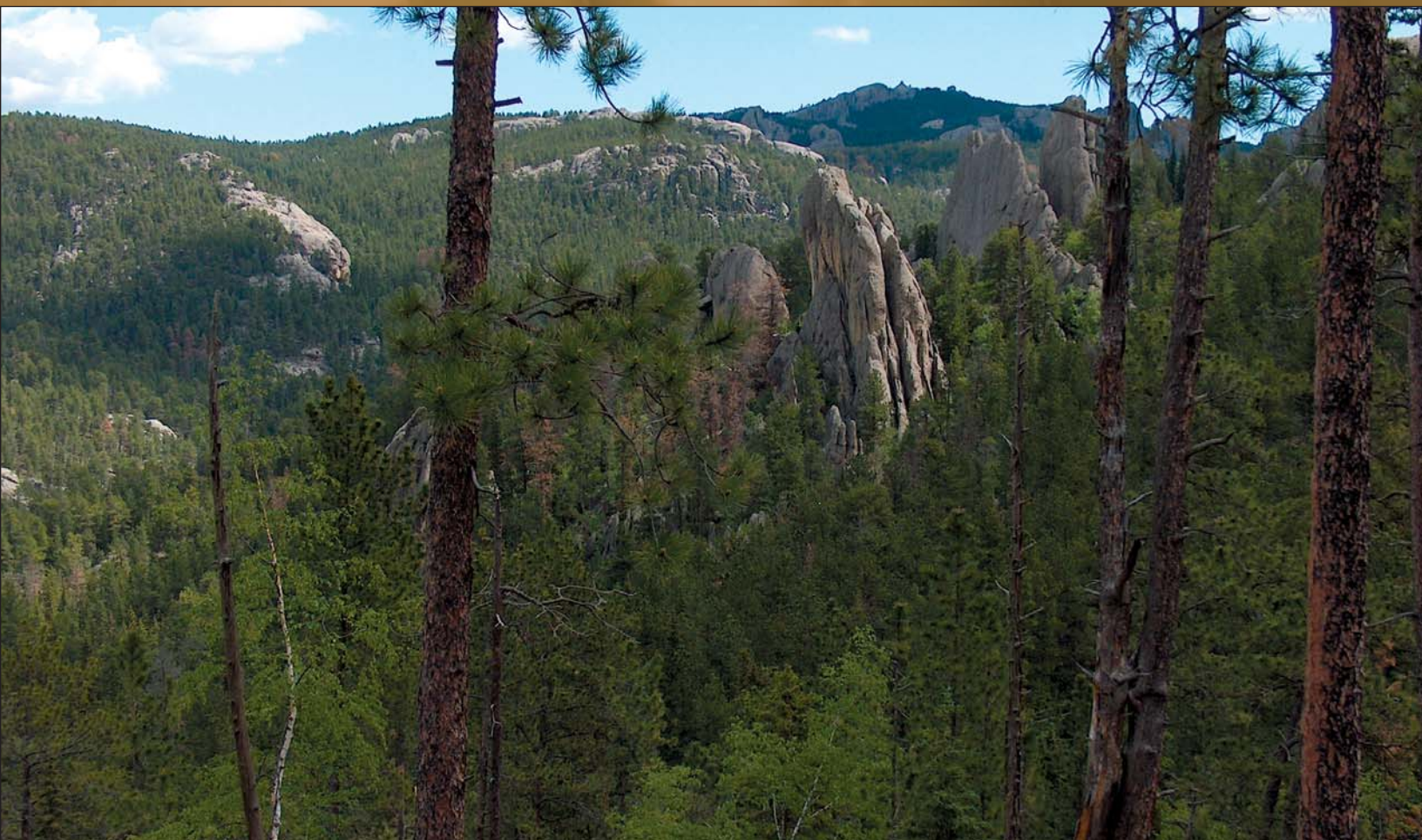


South Dakota's Forests

2005



Resource Bulletin
NRS-35



United States
Department of Agriculture



Forest
Service



Northern
Research Station

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Note: Core tables, a glossary, and sample quality assurance/control methods will be included in a companion document, Plains States' Forests, 2005: Statistics and Quality Assurance, Resource Bulletin NRS-xx, to be published online only. Data for the South Dakota forest inventory can be accessed at: <http://fiatools.fs.fed.us>

South Dakota's Forests

2005

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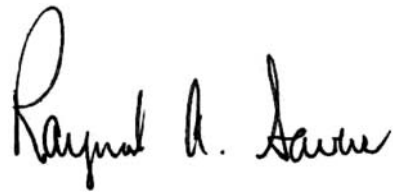
Foreword

Welcome to the first complete description of South Dakota's forest lands based on data from the Forest Inventory and Analysis Program. This report analyzes 5 years of data collected in an annual inventory of 20 percent of State inventory plots. Earlier reports were based on periodic inventories and were limited to different regions of the State. This report is the culmination of an effort between the U.S. Forest Service and the South Dakota Department of Agriculture, Resource Conservation and Forestry Division.

South Dakota has roughly 1.7 million acres of forest land, slightly more than 3 percent of the total land area. The Black Hills region in western South Dakota contains almost 80 percent of the of the State's forest land. The forest types vary from the conifer forests in the west to hardwood forests in the east. The Great Plains divides these two forest types, but this vast grassland also contains a broken latticework of wooded draws, bottomland forests, windbreaks, and community forests.

Management is critical to the health of South Dakota's forests. Removing infested trees and reducing stand density are the most effective means of reducing pine tree mortality resulting from a mountain pine beetle epidemic in the Black Hills. Chipping and prescribed fire can reduce fuel hazards, decreasing the chances of catastrophic fire. Prompt removal of infected American elm is the best way to slow the spread of Dutch elm disease. The emerald ash borer threatens our native ash trees, one of the most abundant tree species in the State. Introduced to this country from Asia, the borer has killed millions of ash trees in the Upper Midwest. There is no known natural defense to stop this invader. We are working to keep emerald ash borer out of the State and have written a plan for action should it be discovered here.

The benefits of South Dakota's forests are real, but so are the threats. The information provided by this inventory, coupled with cooperation, careful planning, and willingness to take action, will allow us to manage our forests wisely. As a result, we can be confident that our forests will be here for the benefit and enjoyment of future generations.

A handwritten signature in black ink, reading "Raymond A. Sowers". The signature is written in a cursive, flowing style.

Ray Sowers, State Forester

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Highlights

On the Plus Side

- Forest land area increased from 1.6 million acres in 1996 to 1.7 million acres in 2005, reversing declines since 1962. Timberland area increased from 1.5 million acres in 1996 to 1.6 million acres in 2005 and is at its highest level since the inventory began in 1935.
- Between 1996 and 2005, forest land area increased by more than 45 percent in the Bad-Missouri-Coteau-James and the White-Niobrara River Basin Areas combined. Forest land area also increased by 7 percent in the Belle Fourche-Grand-Moreau River Basin Area.
- Most species had a crown dieback percentage of 5 percent or less, and foliage transparency was normal in 90 percent of all trees measured. There has been no indication of ozone injury in South Dakota.
- The soil indicator is in its infancy, but the data suggest that while the forest soils of South Dakota are similar to other soils in the region, they are storing above average amounts of carbon.
- Growing-stock volume on timberland increased by 5 percent between the 1996 inventory and the 2005 inventory.
- There is an average of 2 cubic feet of annual net growth of growing stock for every 1 cubic foot of removals. Average annual net growth of growing stock is greater than the average annual removals for all species groups.
- The harvest of timber products has increased by 14 percent since 1999.

Areas of Concern

- Between 1996 and 2005, forest land area decreased by 7 percent in the Cheyenne River Basin Area and by 21 percent in the Minnesota-Big Sioux-Coteau River Basin Area.
- Since 1996, the area of nonstocked forest land has increased by 7 percent, mostly due to recent fires.

- Nearly 50 percent of the forest land falls into the poorly stocked or nonstocked stand categories.
- Between 2001 and 2005, 1.4 million trees were killed by mountain pine beetles and pine engraver beetles.
- The introduction of the banded elm bark beetle is of concern because when these beetles are found in elms with Dutch elm disease, they may be able to spread the disease to other American elm trees.
- Eastern redcedar and Rocky Mountain juniper have many wildlife benefits and are an important component of field windbreaks and living snow fences. However, they can have a negative effect on grassland nesting birds, take water from surrounding grasslands and streams, produce a shading effect that inhibits native grasses, and reduce livestock forage.
- Common buckthorn was the most prominent of the non-native invasive species and was found on hardwood plots in eastern South Dakota. Where this species becomes established, it tends to dominate the forest understory, making it impossible for native plants to thrive.



Issues to Watch

- More than 80 percent of the cottonwood forest type is in the large stand-size class with little regeneration. If this condition persists, cottonwood stands will become overmature, 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 along with associated mortality rates, the ratio of average annual net growth of growing stock to average annual removals may be adversely affected.

- Ash trees, an important component of South Dakota's forests, windbreaks, and urban areas, are vulnerable to future emerald ash borer infestations and need to be monitored.
- Fifty percent of the family forest land is owned by people 65 years of age or older. A large-scale intergenerational shift may occur when this land is passed on to heirs or sold. This trend will change the characteristics of the family forest owners, influence how owners interact/relate to their land, and may alter future forest characteristics.
- The only health decline issue in crown conditions appeared with quaking aspen. Quaking aspen is a relatively short-lived species, and more than 45 percent of the aspen/birch forest type is over 60 years old. The high percent of crown dieback and foliage transparency may indicate that these stands are beginning to decline due to insect and disease problems associated with older aspen forests.
- The increasing use of biobased material from agriculture crops to produce liquid transportation fuels and biodegradable products could lead to the removal of windbreaks or wooded strips along streams or rivers and replacement by row crops. Most windbreaks or wooded strips don't qualify as forest under the 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.

Background



A Beginners Guide to Forest Inventory

What is a tree?

We all know a tree when we see one, so we can agree on some common tree attributes. Trees are perennial woody plants that have central stems and distinct crowns. In general, a tree is defined by FIA 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 Plains States' Forests 2005: Statistics and Quality Assurance, the companion report to this document, available online at: www.nrs.fs.fed.us.

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 important question: Where does the forest end and the prairie begin? 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 one 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 1.7 million acres of forest land in South Dakota, 92 percent is timberland, 3 percent is reserved forest land, and 5 percent is other forest land.

Timberland is forest land that is not reserved and meets minimum productivity requirements. Reserved forest land is land that has been withdrawn from timber utilization through legislation or administrative regulation. Most of the reserved forest land in South Dakota is in the Black Elk Wilderness and Wind Cave National Park. The other forest land in South Dakota is typically found on sites with poor soils where the forest is incapable of producing 20 cubic feet of wood per acre per year (sometimes referred to as unproductive forest land).

In prior inventories only trees on timberland plots were measured so volume on all forest land could not be reported. 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. With the remeasurement of these annual plots in subsequent years, we will also be able to report growth, removals, and mortality on all forest land.

How many trees are there in South Dakota?

There are approximately 211.9 million live trees on South Dakota's forest land (give or take a few thousand) that are at least 5 inches in diameter as measured at 4.5 feet above the ground. We do not know the exact number because we only measured about 1 out of every 36,000 trees¹. In all, 6,056 trees at least 5 inches in diameter were sampled on 306 forested plots. For information on sampling errors see Plains States' Forests, 2005: Statistics and Quality Assurance, the companion report to this document, available online at: www.nrs.fs.fed.us.

How do we estimate a tree's volume?

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 more efficient, was the method used by the Northern Research Station. In this method, several hundred cut trees were measured taking detailed diameter measurements along their lengths to accurately determine their volumes (for ponderosa pine – Myers 1964; for all other species – Hahn 1984). Regression lines were then fit to this data by species group. Using these regression equations, we can produce individual tree volume estimates based on species, diameter, and tree site index.

The same method was used to determine sawtimber volumes. FIA reports sawtimber volumes in International 1/4-inch rule board foot scale. Conversion factors for converting to Scribner board foot scale are also available (Smith 1991).

How much does a tree weigh?

The Forest Products Laboratory of the U.S. Forest Service developed specific gravity estimates for a number of tree species (USDA 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), 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, one ton of oven-dry biomass is equal to 1.9 tons of green biomass.

¹ During the course of the 2001-2005 inventory of South Dakota, we measured four 1/24-acre subplots (for a total area of 1/6 acre) for approximately every 6,000 acres of forest land.

How do we compare data from different inventories?

Data from new inventories are often compared with data from earlier inventories to determine trends in forest resources. However, for comparisons to be valid, procedures used in the two inventories must be similar. As a result of FIA's ongoing efforts to improve the efficiency and reliability of the inventory, several changes in procedures and definitions have occurred since the last South Dakota inventory in 1996. 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 2001-2005 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 Research Station 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 2001-2005 inventory 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. 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 because laws, regulations, voluntary guidelines, physical constraints, economics, proximity to people, and ownership objectives may prevent timberland from being available for timber production.

Forest Features



Area 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 economical 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 currently estimated at 1.7 million acres, slightly more than 3 percent of the total land area in South Dakota (Table 1, Fig. 1). Eighty percent of the forest land is located in the two westernmost River Basin Areas (RBA), the Belle Fourche-Grand-Moreau and the Cheyenne, which account for only 35 percent of the total land area in the State. Forest land area increased by 42,000 acres between the last inventory (1996-land outside the Black Hills National Forest (BHNF) and 1999-BHNF, hereafter referred to as the 1996 inventory) and the current inventory (2005) (Fig. 2). The first inventory of forest land in South Dakota in 1935 was designed primarily to determine the proper relation of farm forestry to other phases of farm management. Since the 1935 inventory, the area of forest has remained around 1.7 million acres, dropping slightly to 1.6 million acres in the 1996 inventory.

What this means

Severe weather 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 the plantings of many of the windbreaks, shelterbelts, and farm woodlots that are still present today. Seasonal flooding led Congress to pass the Flood Control Act of 1944, which authorized the construction of dams on the Missouri River. The four dams constructed on the Missouri 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 diseases, grazing, and aerial application of agricultural herbicides. Dutch elm disease has taken a toll on American elm, once a dominant species in riparian wooded areas. On the other hand, increased fire protection has allowed the forest to encroach into the rangeland and grasslands of the State.

What the future holds for the forest land in South Dakota is hard to predict. Two possible scenarios are 1) the increased demand for liquid transportation fuels such as ethanol and

biodiesel from short rotation agricultural crops could increase tillage and reduce forest land area as more land is cleared for planting, and 2) livestock farming may decrease as the cost of feeding the animals increases. Less livestock grazing could encourage trees to become established on rangeland, thereby increasing forest land area.

Figure 1.—Distribution of forest land by River Basin Area in South Dakota, 2005.

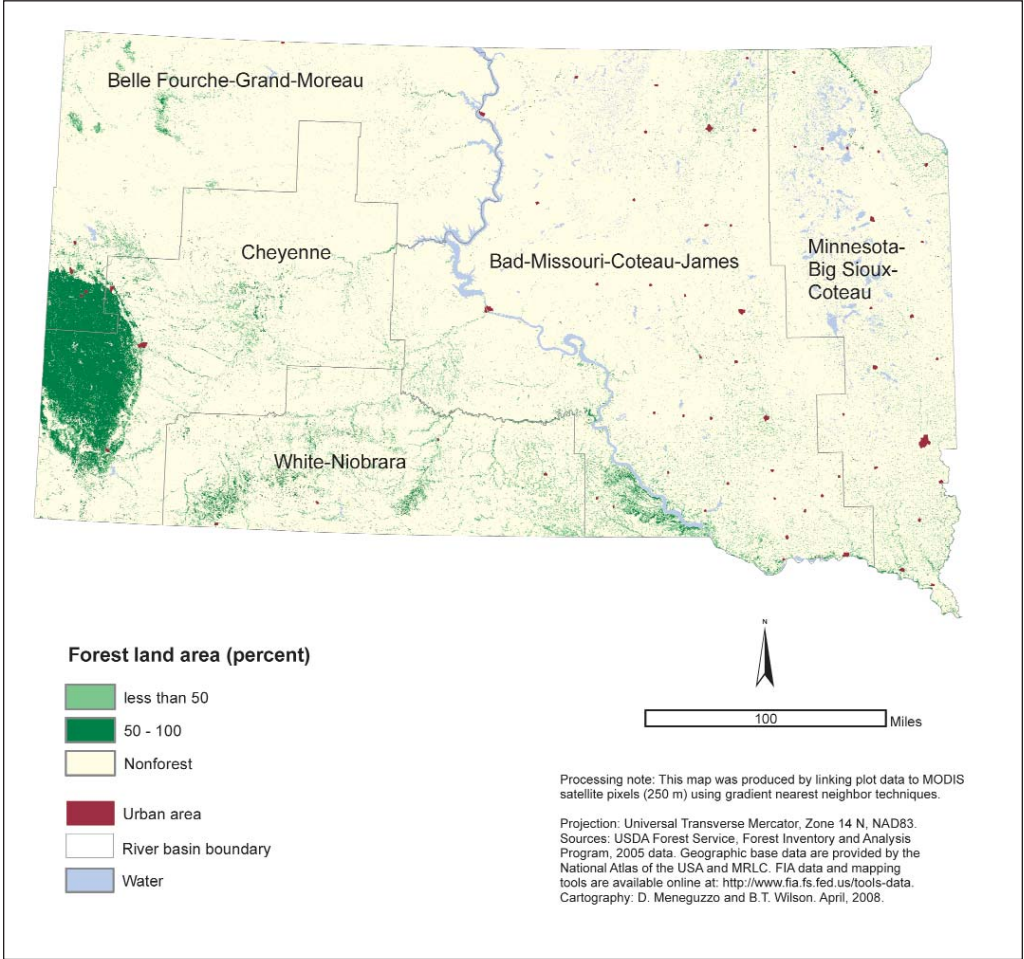


Figure 2.—Area of forest land in South Dakota by inventory year. (The vertical lines at 1996 and 2005 represent the sampling errors associated with those estimates. Sampling errors are not available for the 1935, 1962, and 1984 inventories.)

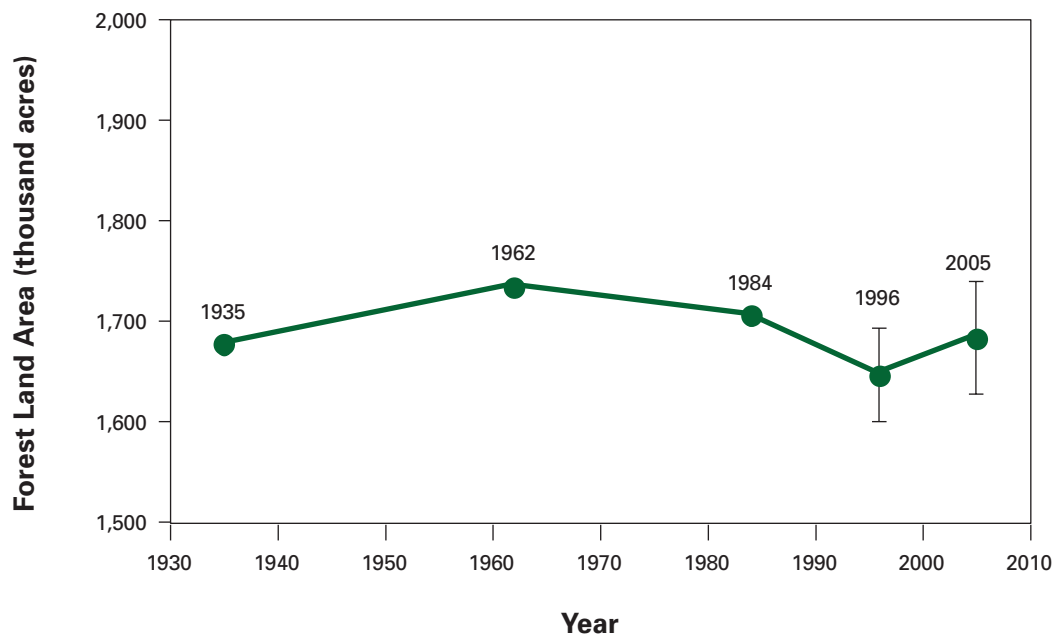


Table 1.—Area of land in South Dakota by land status and River Basin Area, 2005, in thousand acres.

River Basin Area	Forest land					Nonforest land
	Total all land	Total forest land	Timberland	Reserved forest land	Other forest land	
Bad-Missouri-Coteau-James	17,163.5	121.8	102.5	--	19.4	17,041.6
Belle Fourche-Grand-Moreau	8,514.6	397.7	378.5	--	19.2	8,116.9
Cheyenne	8,526.9	944.7	881.1	42.0	21.6	7,582.2
Minnesota-Big Sioux-Coteau	7,874.8	49.0	44.6	0.0	4.3	7,825.9
White-Niobrara	6,041.1	168.8	145.7	--	23.1	5,872.3
Total	48,120.9	1,682.1	1,552.4	42.0	87.6	46,438.8

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

Timberland

Background

FIA separates forest land into three components: timberland – forest land that is capable of producing 20 cubic feet of wood per acre per year and is not restricted from harvesting by statute, administrative regulation, or designation; reserved forest land – land restricted from harvesting by statute, administrative regulation, or designation (e.g., national parks and wilderness areas); and other forest land – low productivity forest land not capable of producing 20 cubic feet of wood per acre per year and not associated with urban or rural development. More than 90 percent of South Dakota’s forest land is defined as timberland (Fig. 3).

What we found

Timberland has increased by less than 5 percent since its low point in 1984 and is at its highest level since the 1935 inventory. Like forest land, South Dakota’s timberland is mostly publicly owned and is dominated mainly by ponderosa pine. Hardwood forest types occur on only 16 percent of the timberland area in the State. Two-thirds of the timberland area is stocked with large-diameter stands (Fig. 4). Medium- and small-diameter stands make up only 27 percent of the timberland area. The remaining 6 percent of the timberland in South Dakota is nonstocked. Nonstocked timberland is timberland that is less than 10 percent stocked with all live trees. These areas have been harvested or burned and tree regeneration is currently unestablished.

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 cottonwood forest type, for every 5 acres of large-diameter stands, there is only 1 acre of small- or medium-diameter stands. For ponderosa pine and white spruce forest types, this ratio is only slightly better at 3 to 1. Without substantial disturbances, especially in hardwood stands, stands have not been opened for progressive seedling development. Some smaller trees are prevented from maturing properly by large overstory trees.

The number of small-diameter stands is expected to increase in the near future. Recent fires in the Black Hills are a cause for the increase in nonstocked stands. As these burned-over areas heal, tree seedlings should begin to regenerate into new forests. However, some of these fires were large and intense so it may require many years before forests become fully stocked.

Figure 3.—Area of forest land by timberland, reserved forest land, and other forest land in South Dakota, 1996 and 2005.

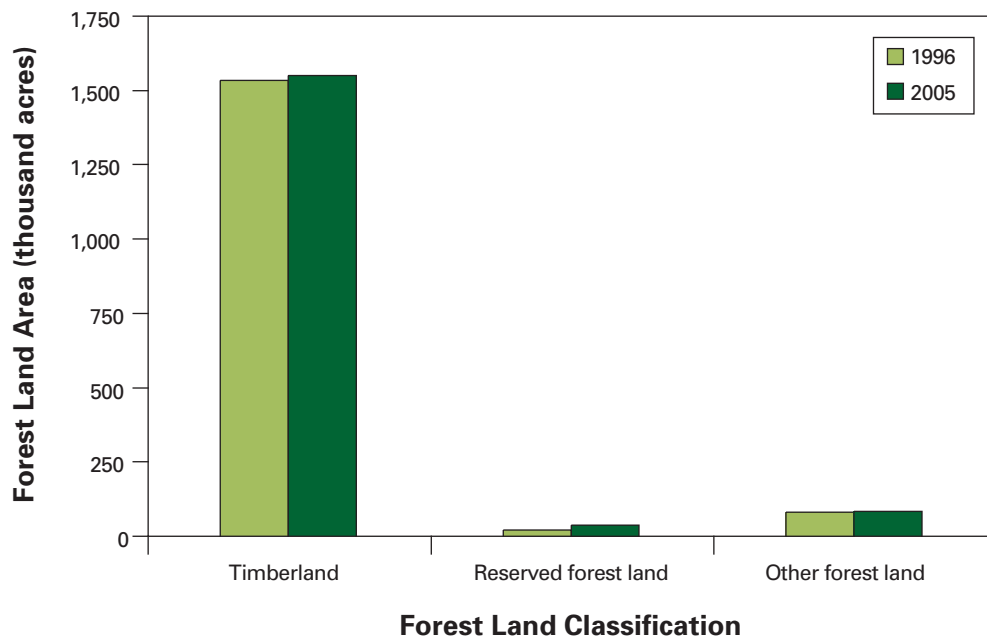
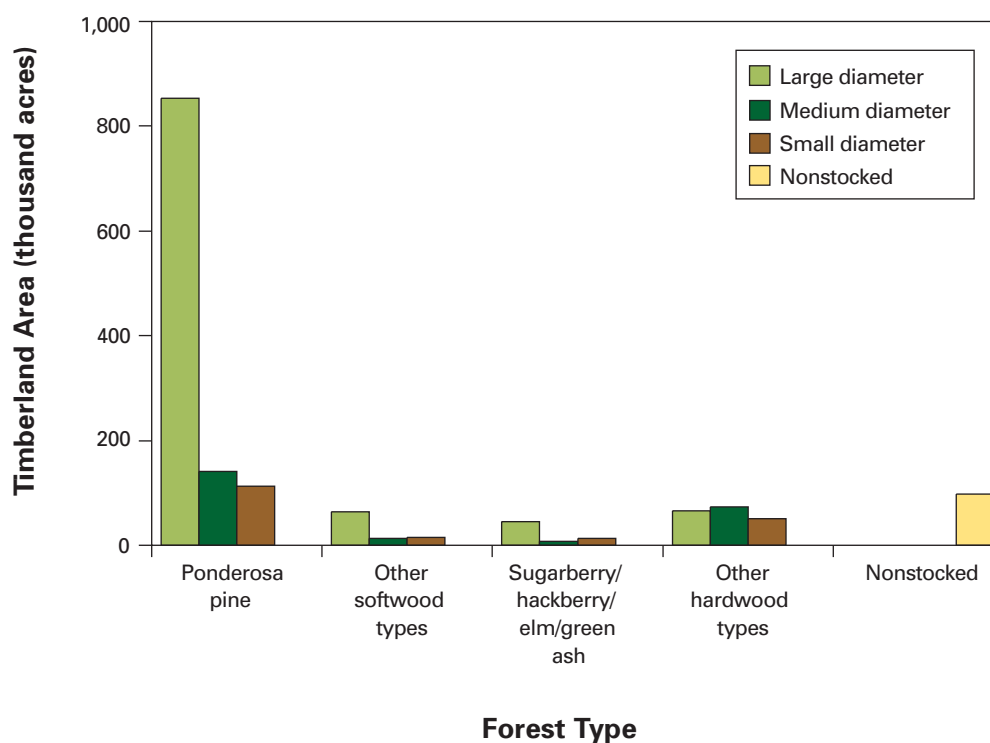


Figure 4.—Area of timberland by forest type and stand-size class in South Dakota, 2005.



Other Treed Land

Background

FIA defines forest land as land that is at least 10 percent stocked by trees of any size or formerly having had such tree cover and not currently developed for nonforest use. The area with trees must be at least 1 acre in size and at least 120 feet wide to qualify as forest land. However, many treed areas in South Dakota do not meet this definition, yet these trees are an important resource where forest land is scarce or agriculture dominates the landscape. Uses of this land are cropland with trees, pasture and rangeland with trees, wooded strips, idle farmland with trees, marsh with trees, narrow windbreaks (<120 feet wide), shelterbelts, and urban land with trees.

What we found

We estimated that, in addition to forest land, there are 563,900 acres of treed lands in South Dakota. In the Bad-Missouri-Coteau-James RBA and the Minnesota-Big Sioux-Coteau RBA, treed land area is greater than forest land area (Fig. 5). Additionally, if Lawrence County, which contains nearly 90 percent of the forest land area in the Belle Fourche-Grand-Moreau RBA, is omitted, this RBA would also contain more treed land than forest land.

What this means

In South Dakota, where the forest land is highly concentrated in one area of the State, treed lands are an important resource. Nonforest land trees help protect soils from erosion; provide protection to wildlife and livestock; protect buildings; provide nuts, fruit and other food for wildlife, livestock, and people; protect roadways; and create visual diversity across the landscape.

More than 60 percent of the treed land area is in pasture and rangeland with trees (Fig. 6). Much of this finding is due to the expansion of eastern redcedar and Rocky Mountain juniper into once open pasture and rangeland. These species can have both positive and negative impacts on of livestock management. Their expansion can cause a loss of forage production, as well as problems in handling livestock. Conversely, they provide shade to the livestock, shelter from wind, and control soil erosion. If the trees continue to expand into pastures and rangeland, these areas that now have scattered trees will begin to have sufficient stocking levels to be classified as forest land.

Figure 5.—Area of treed land and forest land by River Basin Area in South Dakota, 2005.

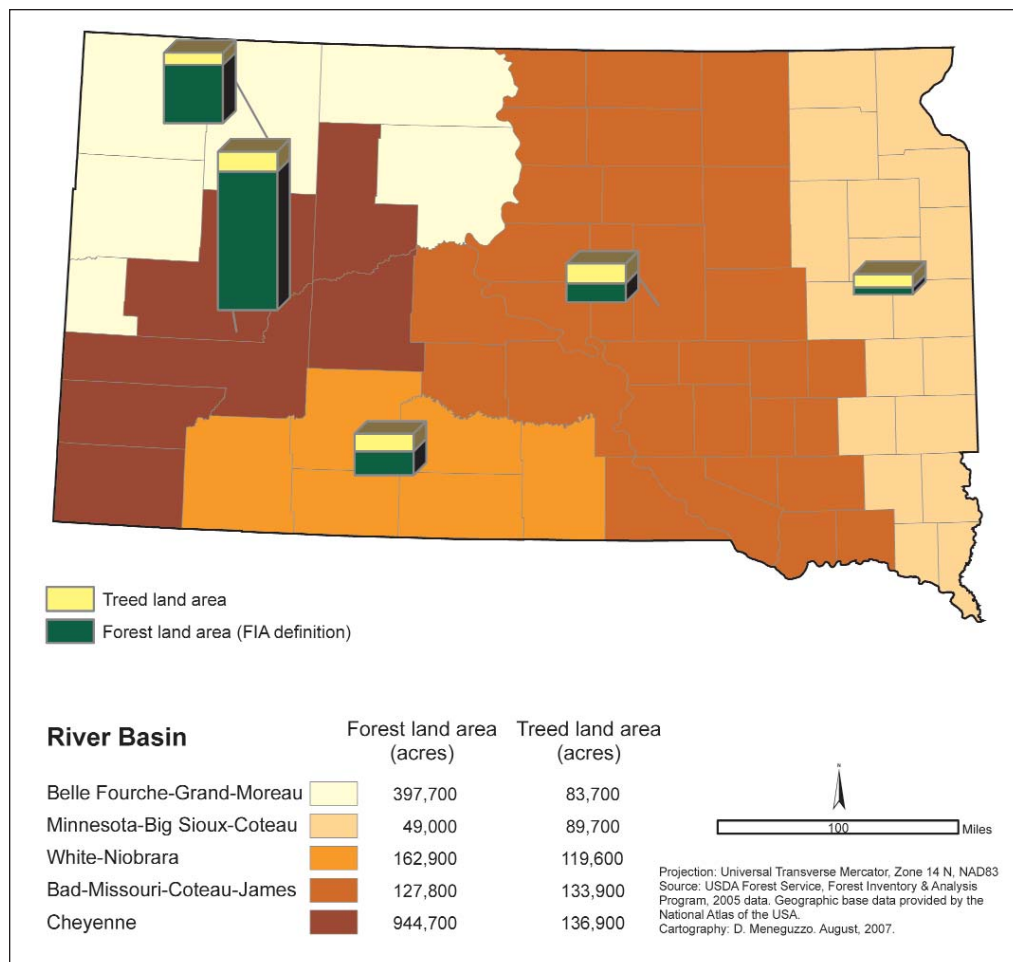
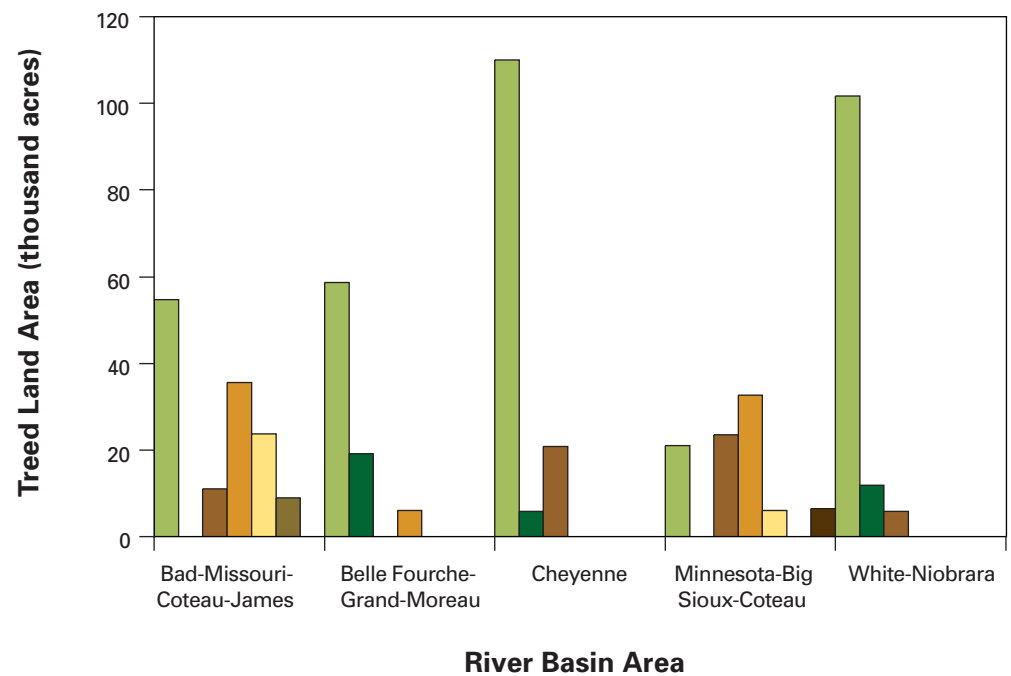


Figure 6.—Area of treed land by River Basin Area and land use in South Dakota, 2005.



Use of treed land

- Pasture and rangeland with trees
- Wooded strip
- Urban and other with trees
- Narrow windbreaks (<120 ft.)
- Shelterbelts
- Cropland with trees
- Marsh with trees

Ownership

Background

The fate of South Dakota's forest lies in the hands of the people, organizations, and governing bodies who own it. 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

More than 70 percent of the forest land in South Dakota is in public ownership (Fig. 7). The Forest Service is the largest forest land owner with more than 60 percent of all of the forest land in the State in two national forests. 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. Other Federal and State, county, and other local governments own the remaining 10 percent of the public forest land.

More than 50 percent of the privately owned forest land is located in southwestern South Dakota, in Cheyenne and White-Niobrara RBAs. The two eastern RBAs of Bad-Missouri-Coteau-James and Minnesota-Big Sioux-Coteau contain only 9 percent of the forest land in the State, but more than 90 percent of that is privately owned.

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. All of the reserved land lies within the Cheyenne RBA. On this land natural processes occur without interference from humans and timber harvesting is restricted.

Ownership of hardwood and softwood forest types is nearly reversed. A little over 80 percent of the softwood forest types are found on publicly owned forest land while nearly 75 percent of the hardwood forest types are found on privately owned forest land (Fig. 8). The western three RBAs contain 99 percent of both the forest land area in softwood forest types and the publicly owned forest land in the State.

Figure 7.—Area of forest land by River Basin Area and ownership in South Dakota, 2005.

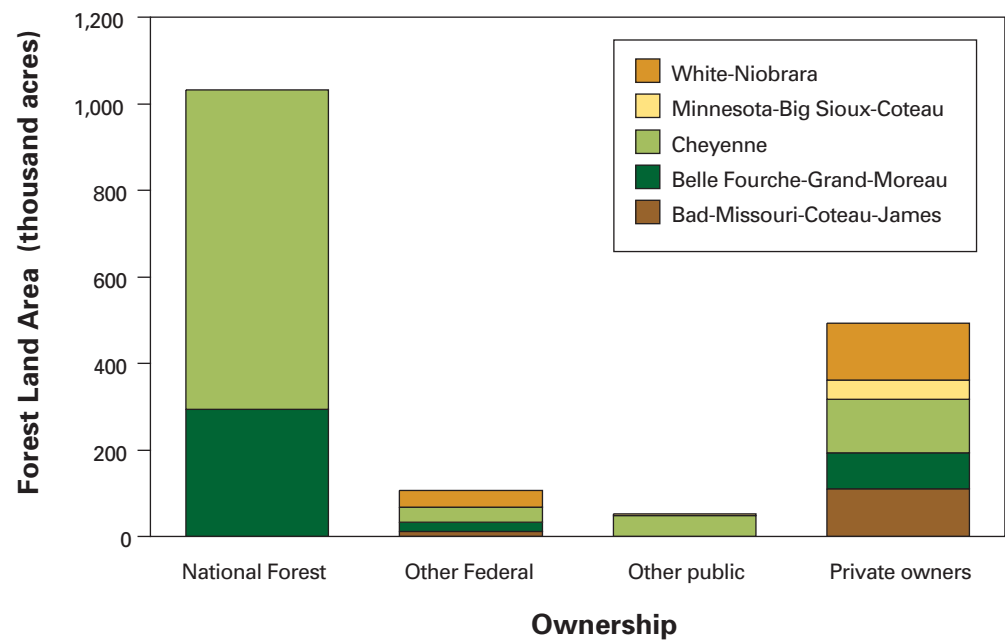
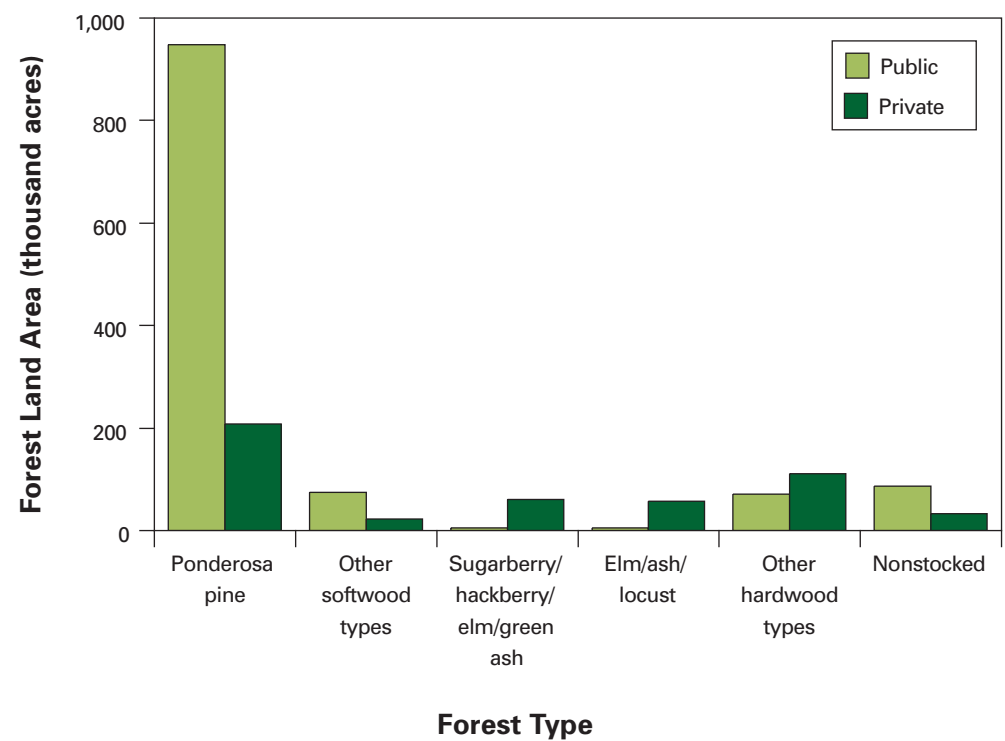


Figure 8.—Area of forest land by forest type and ownership group in South Dakota, 2005.



Family Forest Owners

Background

South Dakota's family forest land owners are stewards of an important resource that provides both personal and societal benefits. As stewards, landowners maintain their woodlots to protect and enhance their personal interest while providing environmental and other benefits to the public. Owners' relationships with their forests have important implications for resource sustainability, including the sustainable production of timber and the continued flow of goods and services.

What we found

An estimated 13,000 families and individuals own 352,000 acres of forest land in South Dakota. The National Woodland Landowner Survey conducted by the U.S. Forest Service found that, although the majority (68 percent) of family forest owners have fewer than 10 acres of forest land, the majority (85 percent) of the family forest land is owned by people with landholdings of 10 acres or more (Fig. 9).

Family forest owners have diverse ownership objectives. The most common reasons for owning forest land are enjoying beauty/scenery, protecting nature, and maintaining a legacy to pass on to heirs (Fig. 10). Other common reasons for forest ownership include hunting, fishing, and keeping the forest land as part of a farm or ranch.

Concerns for South Dakota family forest owners include property taxes and ability to keep their landholding intact for their heirs (Table 2). Other prevalent concerns are related to insects, plant diseases, and having to deal with endangered species.

What this means

Although most family forest owners in South Dakota plan to do little with their forest land in the near future, about 1 in every 4 acres is owned by someone who plans to either transfer the land to an heir or otherwise sell it within the next 5 years (Table 3). This finding is related, in part, to the age of the owners. Thirty percent of the family forest land is owned by people 75



Farmstead in South Dakota. Photo used with permission by Gregory Josten, South Dakota Department of Agriculture.

years of age or older and 20 percent is owned by people between 65 and 74 years of age (Table 4). This impending large-scale intergenerational shift will change the characteristics of the family forest owners; influence how owners view, interact, and relate to their land; and, as a result, may alter future forest characteristics.

Figure 9.—Distribution of family forest owners by size of forest holding in South Dakota, 2005.

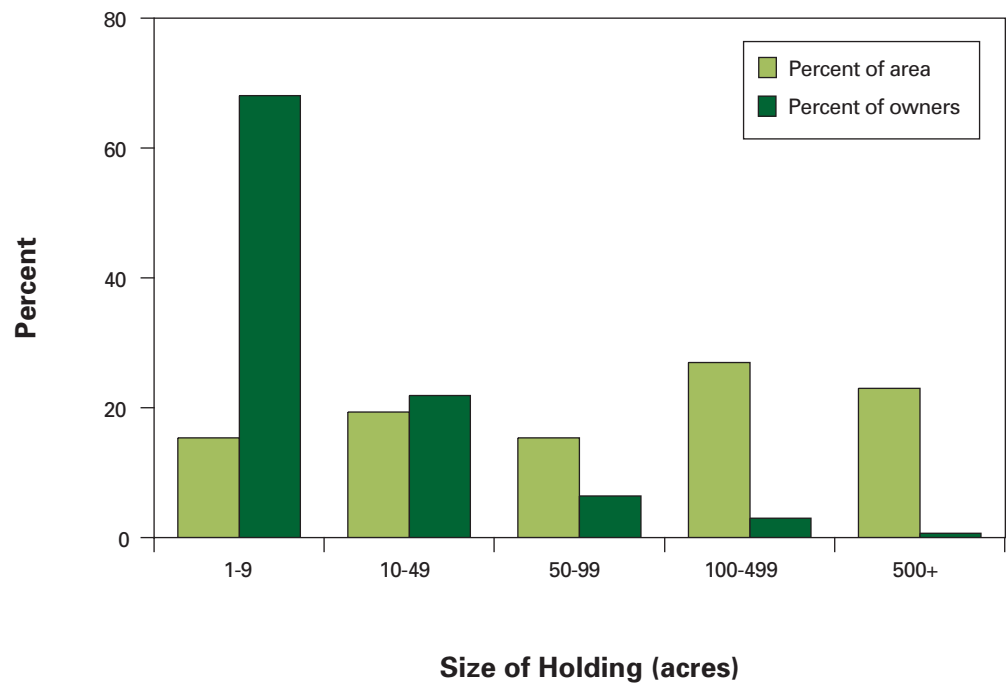


Figure 10.—Area of family owned forests by reason for ownership in South Dakota, 2005. (Categories are not exclusive.)

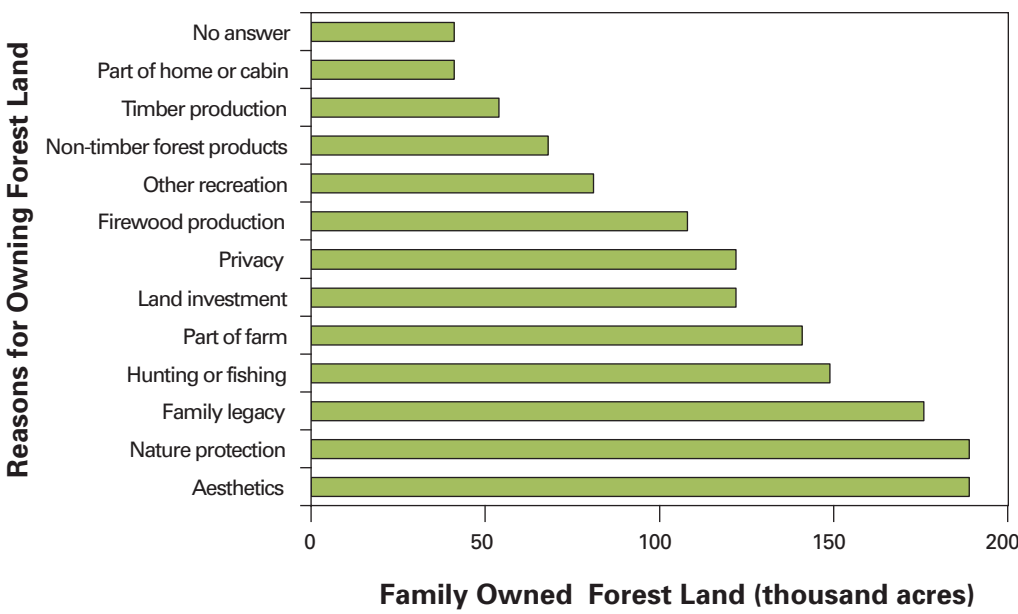


Table 2.—Area and number of family owned forests in South Dakota by landowners' concerns, 2005 (numbers include landowners who ranked each issue as a very important (1) or important (2) concern on a seven-point Likert scale).

Concern ^a	Area		Ownerships	
	Acres (thousands)	Sampling error (%)	Number (thousands)	Sampling error (%)
Property taxes	235	23	4	50
Family legacy	184	30	4	77
Insects/diseases	168	34	5	70
Endangered species	151	37	6	62
Exotic plant species	134	41	1	66
Fire	134	41	5	71
Storms	134	41	3	51
Trespassing	117	47	1	68
Land development	84	62	2	63
Dumping	84	62	1	91
Lawsuits	67	76	1	76
Harvesting regulations	67	76	1	77
Regeneration	67	76	2	84
Timber theft	50	97	1	110
Noise pollution	34	138	1	111
Air or water pollution	34	138	1	99
Domestic animals	34	138	1	99
Wild animals	34	138	1	99

^a Categories are not exclusive.

Table 3.—Area and number of family owned forests in South Dakota by landowners' future (5-year) plans for their forest land, 2005.

Future plans ^a	Area		Ownerships	
	Acres (thousands)	Sampling error (%)	Number (thousands)	Sampling error (%)
No activity	108	48	7	55
Minimal activity	81	61	6	57
Harvest firewood	108	48	2	48
Harvest saw logs or pulpwood	14	313	<1	101
Sell all or part of land	14	313	<1	101
Transfer all or part of land to heirs	81	61	4	77
Buy more forest land	41	113	3	99
Land use conversion (forest to other)	14	313	<1	101
Land use conversion (other to forest)	41	113	5	66
No current plans	27	164	2	99

^aCategories are not exclusive.

Table 4.—Area and number of family owned forests in South Dakota by age of owner, 2005.

Age (years) ^a	Area		Ownerships	
	Acres (thousands)	Sampling error (%)	Number (thousands)	Sampling error (%)
<45	50	97	3	95
45 – 54	17	260	3	114
55 – 64	101	53	5	78
65 – 74	67	76	1	75
75 +	101	53	1	64
No answer	17	260	<1	114

^aCategories are not exclusive.

Tree Species and Forest Types

Background

The species composition of a forest drives the dynamics of its growth, development, and ecosystem function. Some forests are composed of a single tree species; others are composed of many different tree species. Both types of forests provide a variety of ecological niches that various plant and animal communities require. The determination of current species compositions, along with trend analysis, allows us to quantify the character of current and potential forest ecosystems.

What we found

More than 511 million trees over 1 inch in diameter, measured at 4.5 feet above ground (commonly called diameter at breast height or d.b.h.), were found on forest land in 2005. Ponderosa pine was the most common species, with more than 330 million trees, or 65 percent of all trees (Fig. 11). Bur oak was the next most abundant species on forest land, but at 29 million trees, it represents only 6 percent of the total. Other common species included white spruce, quaking aspen, eastern hophornbeam, green ash, and paper birch. Overall, 22 individual tree species were recorded during the forest inventory.

The ponderosa pine forest type dominated South Dakota's forest land in 2005, with nearly 1.2 million acres, or nearly 70 percent of the total forest land area (Fig. 12). The next five forest types, in order of decreasing area, were sugarberry/hackberry/elm/green ash, elm/ash/locust, white spruce, aspen, and bur oak. Combined, these five forest-type groups accounted for only 280,000 acres of forest land, or 17 percent. There were 119,800 acres of nonstocked forest land. Many of the nonstocked areas were the result of fires.

The softwood forest types tend to be in more homogeneous stands, with nearly 80 percent of the area in stands with only one or two different species (Fig. 13). Conversely, 65 percent of the hardwood forest types are in stands that have three or more different species. Sixty percent of the nonstocked stands do not have any trees. At the time of measurement, treeless nonstocked stands were stands that had recently burned and lacked regeneration.

What this means

Because ponderosa pine is the major tree species in South Dakota, much of the forest ecology and forest products economy is based on this species. More than 95 percent of the ponderosa pine trees are located in only five counties in the Black Hills area of South Dakota. Of the State's 25 primary wood-using industries, 16 are located in these counties (Piva et al. 2006). Homogeneous forests that are overstocked and stressed due to drought or old age are susceptible to insect and disease outbreaks. Between 2001 and 2005, an estimated 1.4 million trees were killed by a mountain pine beetle epidemic that is continuing to cause mortality.

The hardwood forest types are scattered throughout the State. The floodplain forest along the Missouri River (where American elm and green ash are the major species) is the largest of these areas. Other areas include the bur oak forests along the upper terraces and draws of rivers, and in the northern Black Hills; the cottonwood forests scattered along the rivers and streams; and the maple and basswood forests of the upland forests in eastern South Dakota.

Figure 11.—Top 10 species in terms of number of live trees 1 inch d.b.h and greater on forest land in South Dakota, 2005.

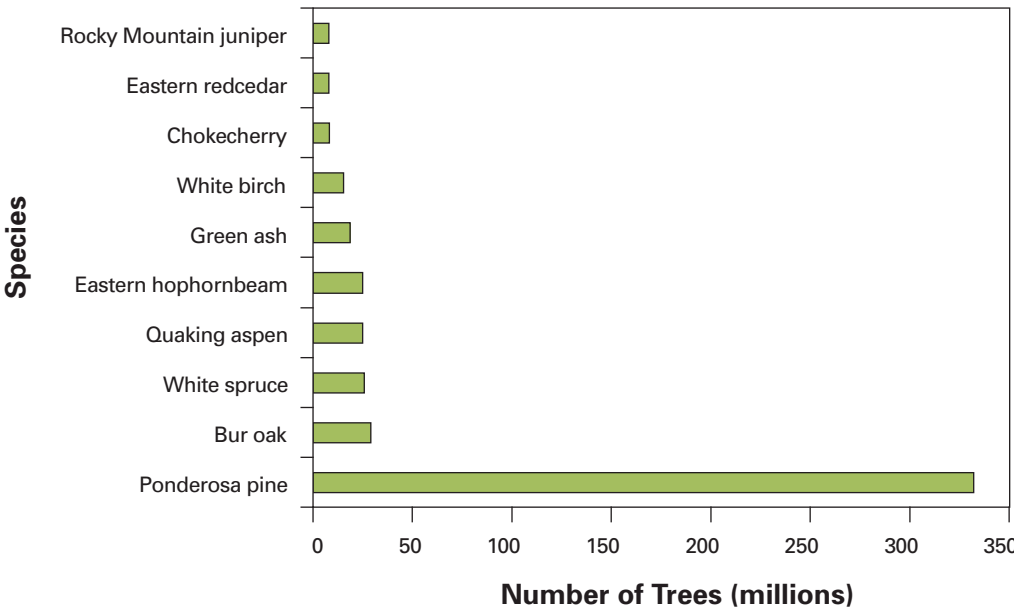


Figure 12.—Distribution of forest land area by forest type in South Dakota, 2005.

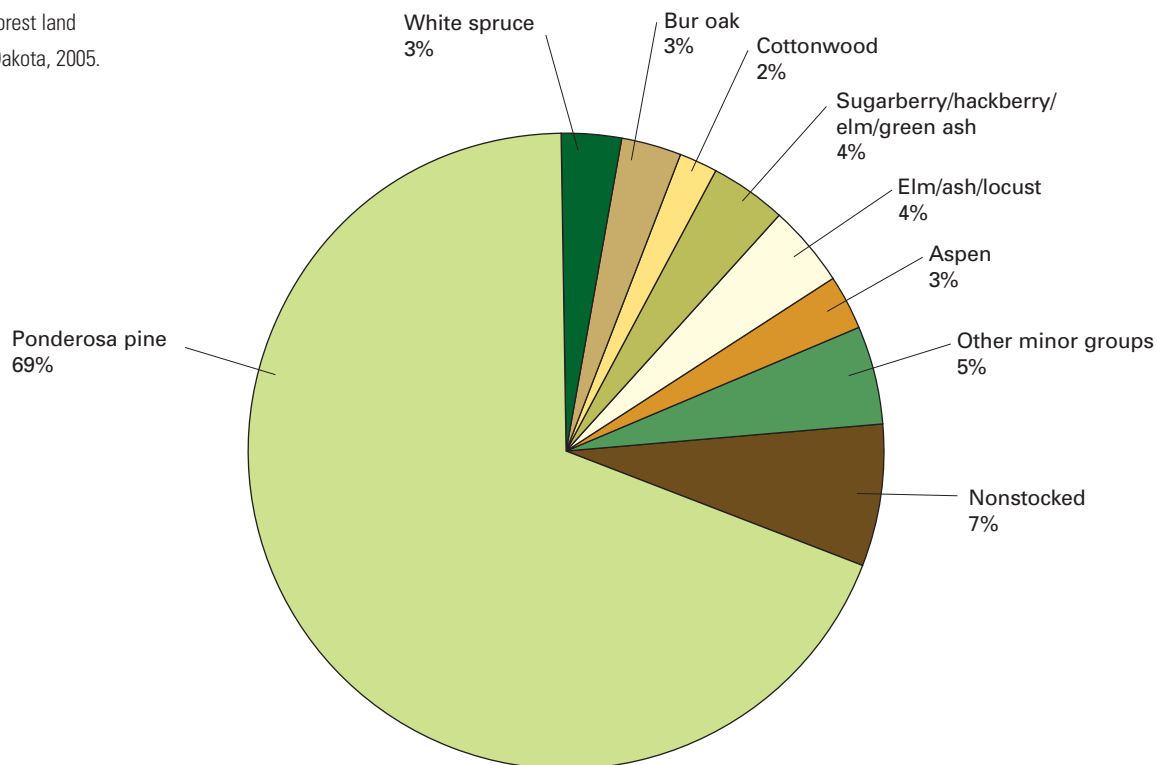
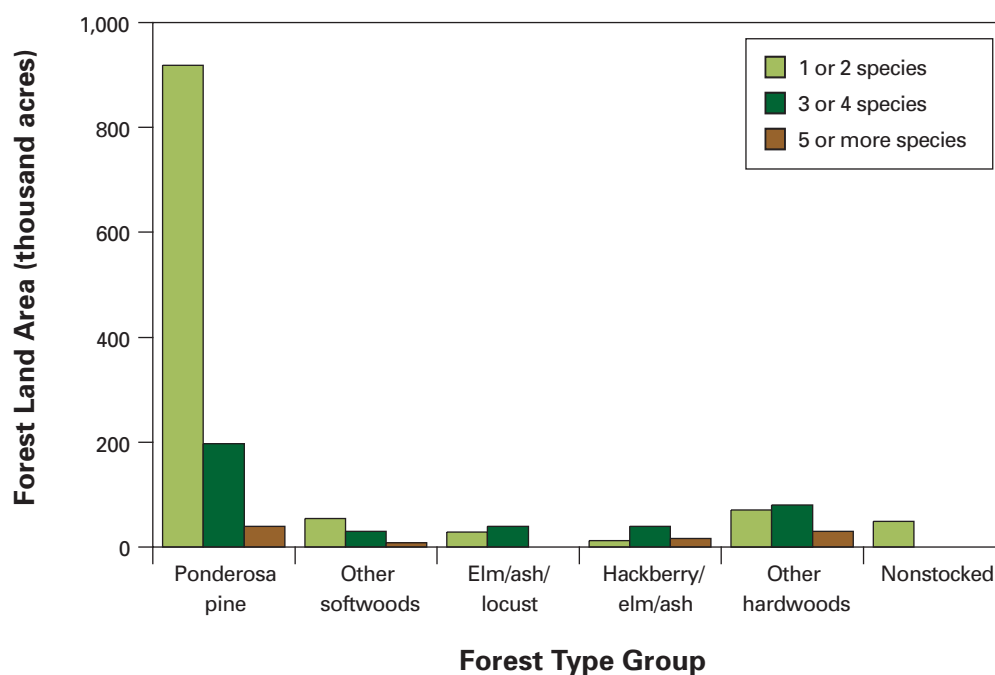


Figure 13.—Area of forest land by forest type and number of tree species in South Dakota, 2005.



Forest Tree Diversity

Background

A forest composed of various tree species, tree sizes, and heights can provide a variety of habitats for wildlife and a range of recreation and aesthetic experiences. A diverse forest, while not completely free of forest health problems, is less likely to be devastated by an insect or disease that attacks a single species or a narrow group of species. Diverse forests may also be more resilient in the face of severe weather disturbances or climate variations.

The Shannon Diversity Index for species combines measures of the number of species and the evenness or relative distribution of those species (Magurran 1988). For example, a forest with five species in which 80 percent of the area is occupied by one species will have a lower Shannon index than a forest with five species in which each of the species occupies a roughly equal proportion of the forest area.

What we found

With a few notable exceptions, those plots with higher levels of Shannon index for species are located in southern and eastern South Dakota (Fig. 14). However, the low-species-diversity ponderosa pine forests of the Black Hills region had high height (Fig. 15) and diameter (Fig. 16) Shannon values.

What this means

Climatic and site productivity factors and other natural disturbances, such as storms, can influence the number of species on a particular site. In South Dakota, there is decreasing overstory diversity in the drier portions of the State. Diversity is also influenced by the competitive abilities of each tree, the collective associations of tree species (“who is next to whom”), and human attempts to direct a forest toward a particular structural or species mix. Forests with greater species, age, or structural diversity are more resilient in the face of a forest health problem that targets a single species or age class.

The plots with the higher species diversity are generally in the remnants of the pre-settlement riparian hardwood-dominated forests in eastern South Dakota. The presence of high height and diameter diversity in the Black Hills likely reflects the open nature of the canopy and the mixed record of harvest in the past. Much light filters through all but the most dense ponderosa pine canopy, allowing younger, smaller pines and other flora to exist in the understory. Grasses, forbs, and herbs in this open understory, combined with needlefall from the pine canopy, create conditions for a fire-maintained disturbance regime that was suppressed only recently by humans. As human habitation increases in the Black Hills and further fire suppression efforts are initiated, we may see a decrease in height diversity as the current understory trees grow into the canopy. Furthermore, increased density should result in competition-induced mortality, thinning out the stand and reducing diameter diversity.

Figure 14.—Shannon Diversity Index for species on NRS-FIA plots in South Dakota, 2005.

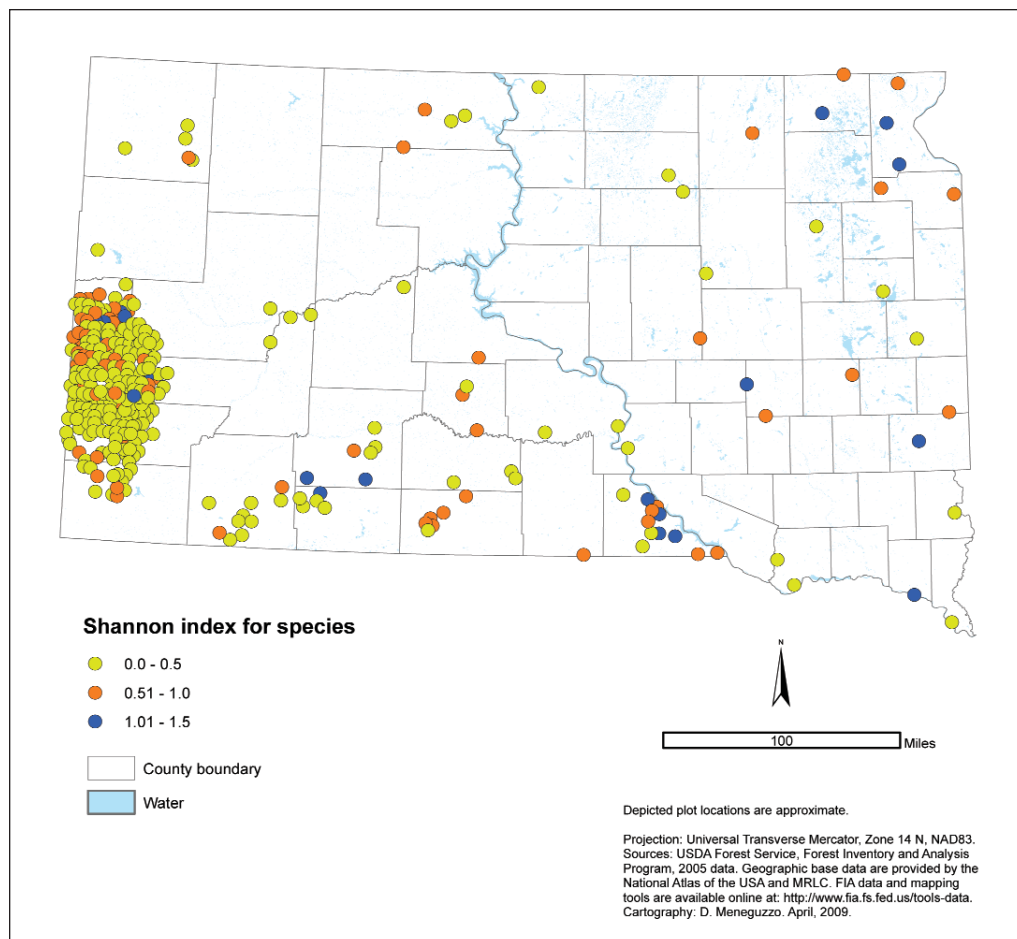


Figure 15.—Shannon Diversity Index for height on NRS-FIA plots in South Dakota, 2005.

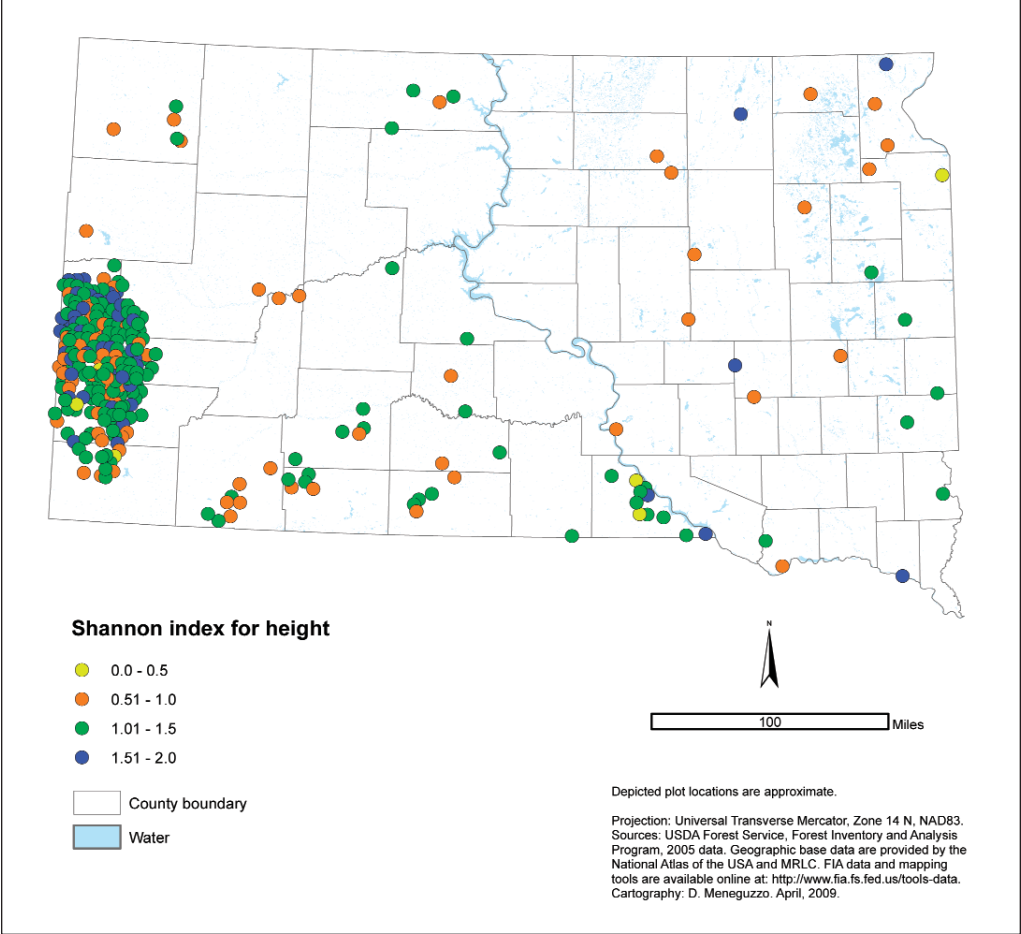
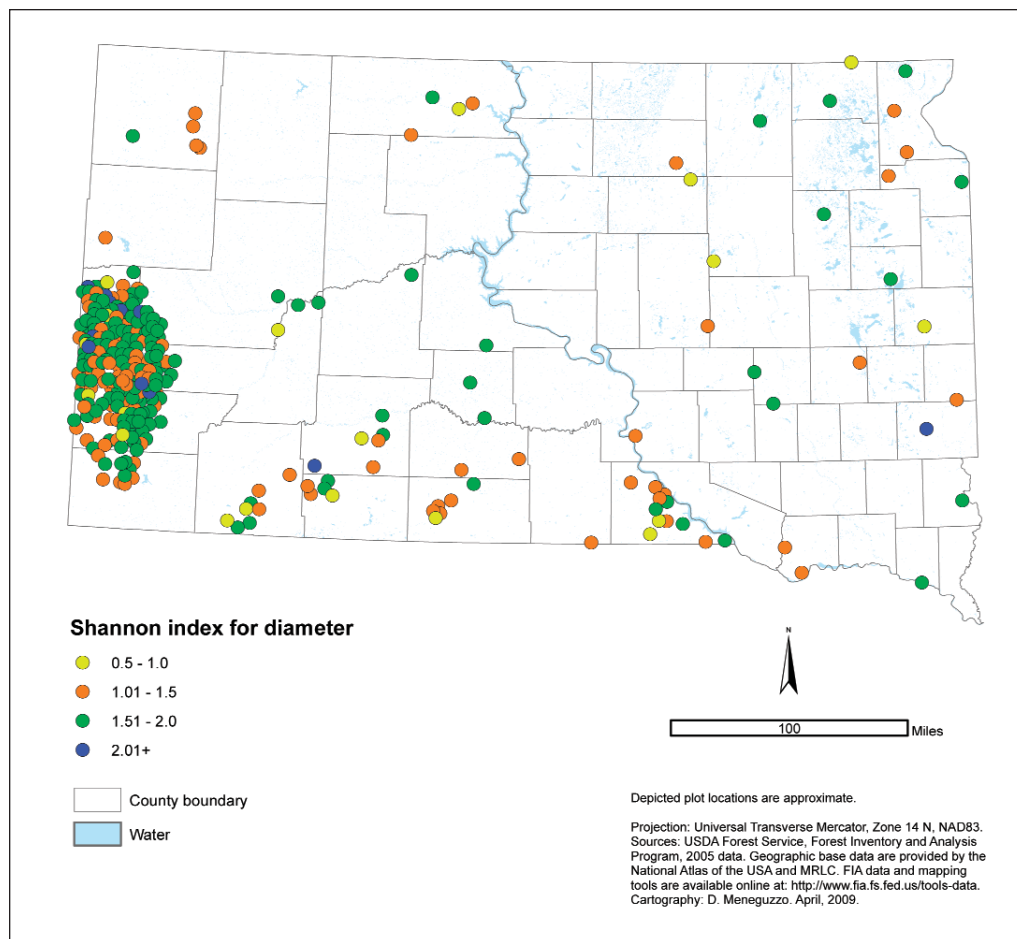


Figure 16.—Shannon Diversity Index for diameter on NRS-FIA plots in South Dakota, 2005.



Expansion of Junipers

Background

Before European settlement, the northern plains were a vast grassland where trees were scarce or absent except in draws and along streams and rivers. These grasslands were maintained by drought, fires, and large, grazing herds of herbivores such as bison. When early European settlers moved onto the plains, they harvested what wood was available for homes, fuel, corrals, and other uses. The rate of harvest was not sustainable and quickly led to the loss of woodlands on the plains. In contrast, fire suppression in the last century has led to the increase of woody vegetation. Eastern redcedar and Rocky Mountain juniper are among the first tree species to become established on abandoned fields and pastures. Eastern redcedar is most commonly found in eastern South Dakota and Rocky Mountain juniper is found mostly in the west (Fig. 17).

What we found

Between the 1996 and the 2005 inventories of forest land in South Dakota, the area of eastern redcedar, Rocky Mountain juniper, and eastern redcedar/hardwood forest types increased by nearly 90 percent, from 22,800 acres in 1996 to 41,400 acres in 2005. Combined, these forest types made up only 2 percent of the total forest land in the State in 2005. Another 9 percent of the forest land not in the eastern redcedar, Rocky Mountain juniper, or eastern redcedar/hardwood forest type had at least one live eastern redcedar or Rocky Mountain juniper tree or seedling per acre.

In 2005, there were almost 58 million eastern redcedar and Rocky Mountain juniper trees and seedlings combined. Only 34 percent of these were in the eastern redcedar, Rocky Mountain juniper, or eastern redcedar/hardwood forest type. The ponderosa pine forest type contained a third of the total number of eastern redcedar or Rocky Mountain juniper trees or seedlings, and the bur oak and mixed upland forest types combined contained another 25 percent. Eastern redcedar and Rocky Mountain juniper were also found in the

elm/ash/locust, sugarberry/hackberry/elm/green ash, and cottonwood forest types and on nonstocked forest land.



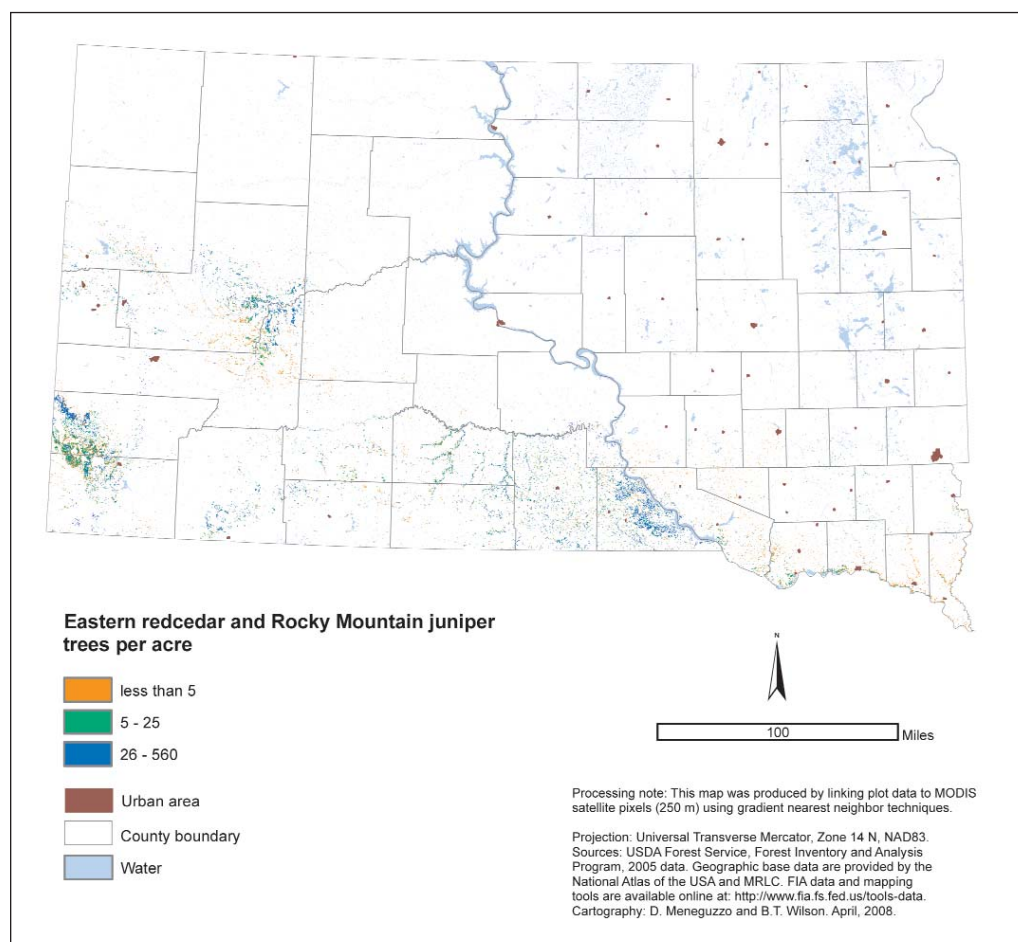
Eastern redcedar and cottonwood. Photo used with permission by Gregory Josten, South Dakota Department of Agriculture.

What this means

Eastern redcedar and Rocky Mountain juniper provide many wildlife benefits, but the establishment of even one tree per acre on native prairie can hinder use of that acre by grassland nesting birds (Johnson 1996). Prairie chickens avoid structures that rise above the grasslands, such as trees, utility poles, or buildings. In addition, one acre of cedar trees can reduce water availability by as much as 55,000 gallons of water per year from surrounding grasslands and streams. Shade from eastern redcedar/Rocky Mountain juniper trees can inhibit the growth of native grasses. This effect on grass, combined with negative effects on the water cycle, greatly reduces the amount of forage available to a livestock producer.

These species may also form closed stands, excluding most other plant species from regenerating. Cottonwood, which is very shade intolerant, is one of the species that would not be able to regenerate with a dense understory of eastern redcedar/Rocky Mountain juniper. The 2005 inventory found that 12 percent of the cottonwood stands in South Dakota had an eastern redcedar/Rocky Mountain juniper component.

Figure 17.—Number of live eastern redcedar/Rocky Mountain juniper trees per acre on forest land in South Dakota, 2005.



Riparian Forests in South Dakota

Background

Riparian forests provide many benefits to South Dakota. They are a critically important habitat for wildlife. They stabilize streambanks and help reduce sediment runoff into rivers and reservoirs that provide water for a significant portion of the State's population. In many parts of South Dakota, riparian forests are the only source of merchantable timber. These forests are also a source of recreation opportunities for the State's population.

What we found

We classified our plots into categories based on the general effect of landform, topographic position, and soil moisture available to trees. These physiographic classes (Table 5) were then grouped into broad categories of xeric, mesic, and hydric sites. Most of the plots in South Dakota are on mesic sites; much of the remainder are on xeric sites (Fig. 18). We grouped mesic sites (other than flatwoods, rolling uplands, and moist slopes and covers) with hydric sites into a “riparian” category. Using this classification, we estimated that there are 118,800 acres of riparian forest land in South Dakota.

Another type of analysis summarizes the pixels on the National Land Cover Dataset for 2001 by cover class. Using this analysis, we estimate there are 1,717,042 acres in deciduous, coniferous, and mixed forests and 277,039 acres in woody wetlands.² While the totals do not exactly match the summaries using NRS-FIA data, they still give evidence of the importance of forested wetlands to the South Dakota landscape.

What this means

Riparian and other water-side sites make up a high percentage of South Dakota's hardwood forest lands. While only 7 percent of the total forest land in South Dakota is immediately adjacent to streams and rivers, most of the forest outside of the Black Hills region is found within a few miles of streams and rivers. Although almost all riparian forests are privately owned, they provide important public benefits to the people of South Dakota.

Riparian forests provide valuable wildlife habitat. Yet, this benefit comes from a vulnerable resource, because fluctuations in water supply can affect the health of forests in riparian zones. Floods can kill trees whose roots become starved for oxygen, but they also replenish the site's productivity through deposition of rich soil. Floods can create new habitats that are quickly colonized by cottonwoods and willows.

² The National Land Cover Dataset (<http://www.epa.gov/mrlc/nlcd-2001.html>) is a remote-sensing derived estimate of different types of land cover in the United States. The NLCD 2001 is the latest product from this analysis. The authors wish to acknowledge Andrew Lister, NRS-FIA, Newtown Square, PA, who provided the analysis of NLCD 2001 for this report. The definitions of the different categories can be found at: <http://www.epa.gov/mrlc/definitions.html#2001>.

Figure 18.—Physiographic class category of NRS-FIA plots in South Dakota, 2005.

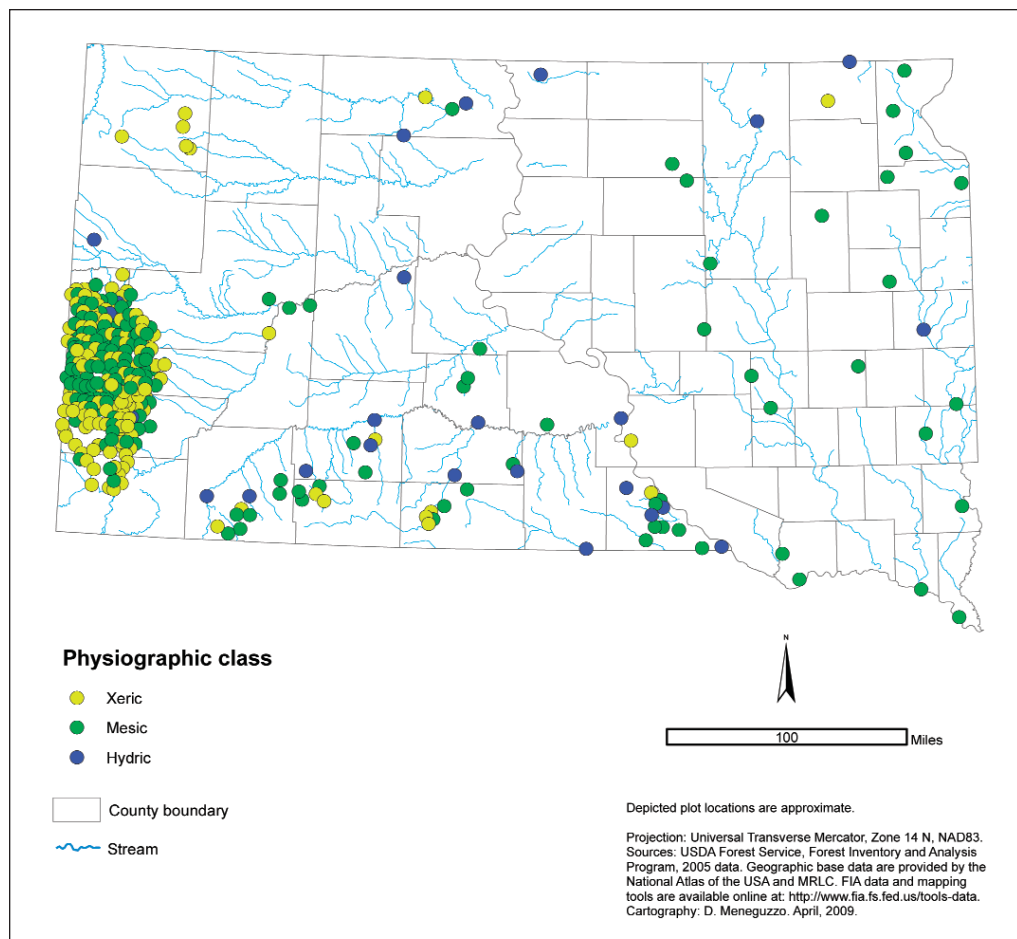


Table 5.—Forest land and timberland area in South Dakota by physiographic class, 2005, in thousand acres.

Physiographic class code	Forest land area	Timberland area	Riparian zone
Dry tops	100.4	87.2	
Dry slopes	635.5	586.8	
Deep sands	5.7	5.7	
Flatwoods	58.1	56.6	
Rolling uplands	724.5	676.4	
Moist slopes and coves	39.2	32.4	
Narrow floodplains/bottomlands	53.6	46.6	Riparian
Broad floodplains/bottomlands	55.1	50.8	Riparian
Other mesic	5.8	5.8	Riparian
Small drains	4.3	4.3	Riparian
Total	1,682.1	1,552.4	

Stand-Size Class

Background

Forests generally 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 – softwood trees at least 9 inches d.b.h and hardwoods at least 11 inches d.b.h.; medium diameter – trees 5 inches d.b.h. to large diameter size; and small diameter – trees less than 5 inches d.b.h. 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 provides information about forest sustainability and succession, wood potentially available for products, wildlife habitat, and recreation potential.

What we found

All of the RBAs, except for the Bad-Missouri-Coteau-James, had more than 60 percent of the forest land area in the large-diameter stand-size class (Fig. 19). The Bad-Missouri-Coteau-James RBA had the greatest percent of its area in medium-diameter stands. All of the RBAs had less than 10 percent of their forest land area in small-diameter stands.

Nine of the 14 forest types had more than half of their forest land area in the large-diameter stand-size class (Table 6). All of the cottonwood/willow forest type that was inventoried was in large-diameter stands. Five forest types had no small-diameter stands inventoried. All of the paper birch forest type stands were in the small-diameter stand-size class.

Large-diameter stands continue to predominate in South Dakota's timberland (Fig. 20). Since 1962, the area of large-diameter stands has increased by 27 percent and now occupies 1.0 million acres, or two-thirds of the timberland area. At the same time, medium-diameter stands have continued to decline, currently occupying 234,700 acres, or 15 percent of the timberland area. The area of small-diameter stands decreased by 46 percent from 1996 to 2005, falling to 190,300 acres, or 12 percent of the timberland area. Six percent of the timberland area was nonstocked in 2005.

What this means

Over the years, forest trees in South Dakota generally have grown larger. The high proportion of total area in large-diameter trees indicates a maturing forest. The expansion of large-diameter stands suggests that harvesting, flooding, or other natural disturbances are reducing few stands to early successional stages. This is seen in the cottonwood, cottonwood/willow, and bur oak forest types, where no small-diameter stands were inventoried. 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 the cottonwood forest types are not regenerating. Instead, other species (e.g., ash, elm, and eastern redcedar) are becoming established in the understory and replacing the cottonwood as it dies out. Bur oaks require disturbance to open the canopy to allow sunlight into the understory. When disturbances do not occur, more shade tolerant species (e.g., ironwood, ash, elm, and eastern redcedar) will outcompete the bur oak saplings/seedlings. Eventually, the bur oak forest type may be replaced with sugarberry/hackberry/elm/green ash or elm/ash/locust forest types.

Figure 19.—Percentage forest land by River Basin Areas and stand-size class in South Dakota, 2005.

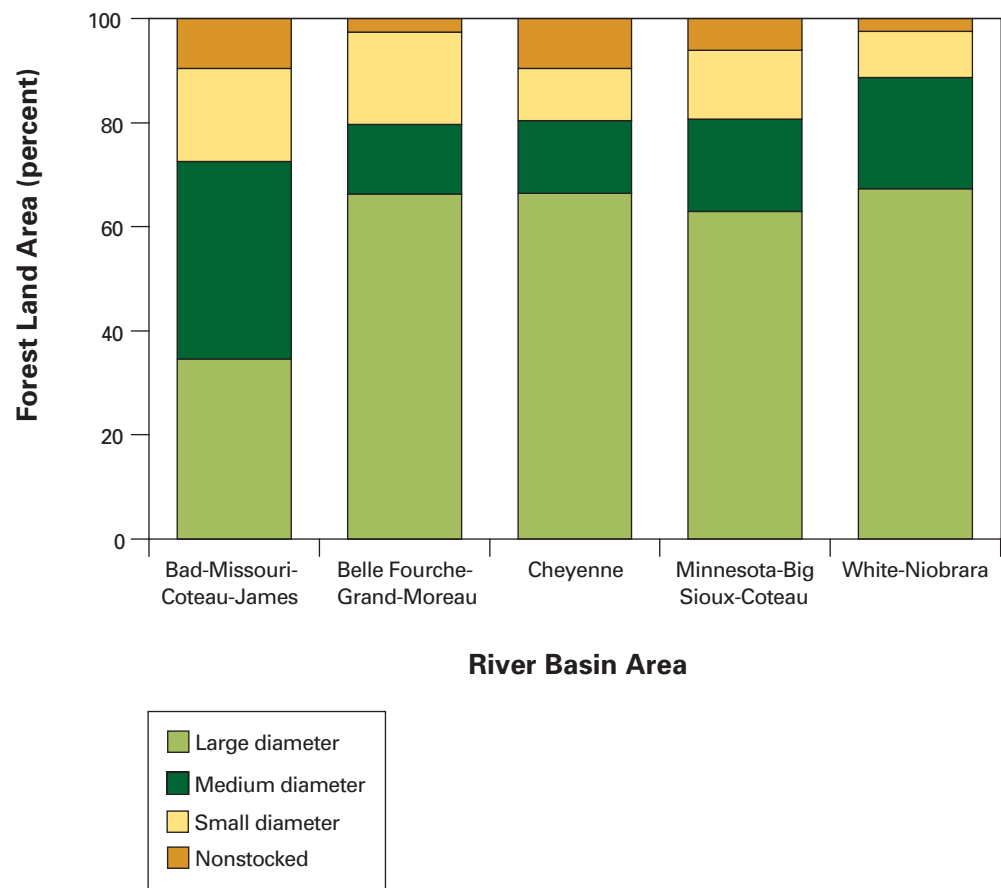
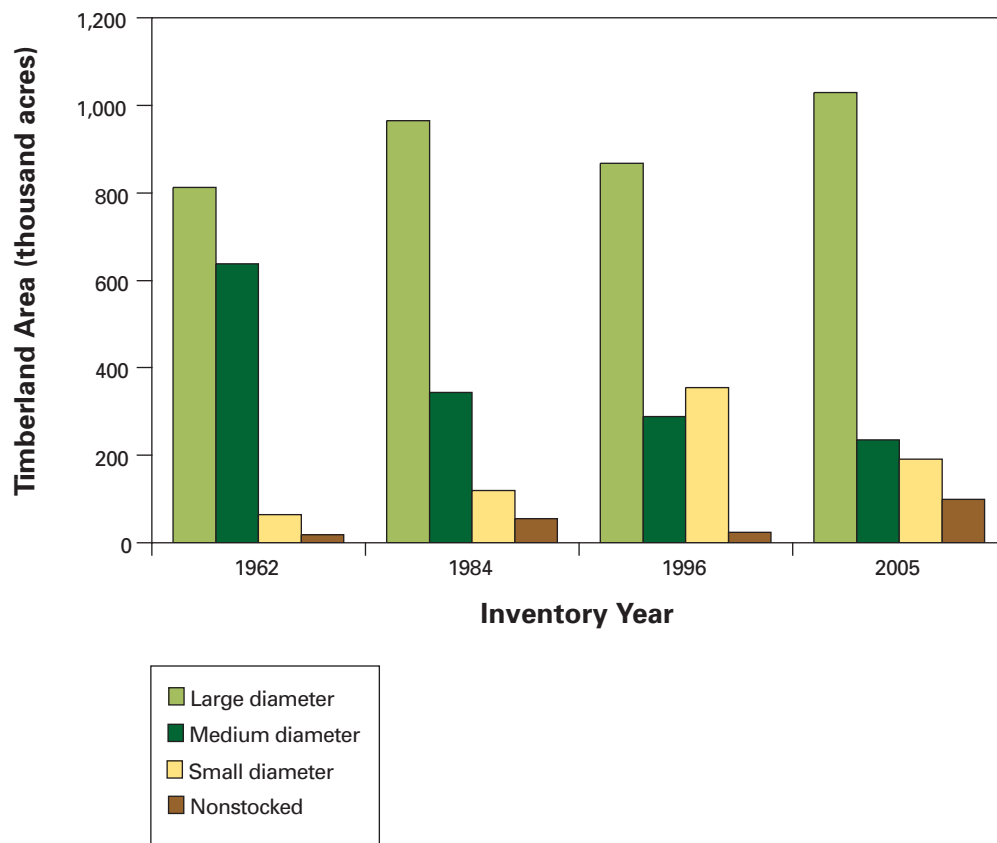


Table 6.—Forest land area by forest type and stand-size class in South Dakota, 2005, in thousand acres.

Forest type	Stand-size class				
	All stands	Large diameter	Medium diameter	Small diameter	Non-Stocked
White spruce	56.0	42.4	6.1	7.5	--
Eastern redcedar	28.0	11.3	5.8	10.9	--
Rocky Mountain juniper	13.4	10.9	1.0	1.6	--
Ponderosa pine	1,154.3	889.3	143.9	121.1	--
Bur oak	42.7	21.5	21.2	--	--
Mixed upland hardwoods	28.8	4.3	5.4	19.1	--
Black ash/American elm/red maple	0.7	--	0.7	--	--
Cottonwood	37.6	30.1	7.4	--	--
Sugarberry/hackberry/elm/green ash	66.8	45.1	8.4	13.4	--
Cottonwood/willow	4.3	4.3	--	--	--
Elm/ash/locust	62.6	12.6	35.1	14.9	--
Aspen	52.0	5.8	30.8	15.5	--
Paper birch	4.3	--	--	4.3	--
Other exotic hardwoods	10.8	--	10.8	--	--
Nonstocked	119.8	--	--	--	119.8
Total	1,682.1	1,077.7	276.5	208.2	119.8

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

Figure 20.—Area of timberland by stand-size class and inventory year in South Dakota.



Stand Age

Background

The age of a forest can determine its growth, suitability for a particular species of wildlife, or potential for economic use. Stand age is closely correlated to stand-size class; the smaller trees tend to be the younger trees and the larger trees tend to be the older trees. Forest age can help us figure out whether a past disturbance was caused by weather, insects, disease, or humans. It can also help us predict the forest's susceptibility and response to disturbance.

What we found

The bulk of South Dakota's forests are less than 90 years old (Fig. 21). Only a few 100+ year-old stands exist, predominantly in the Black Hills. Like much else about South Dakota's forests, the bulk of the older forests, by volume and number of trees, are classified as ponderosa pine forests (Fig. 22). Black Hills spruce, also known as white spruce, had a preponderance of total volume in stands at least 60 years old. Hardwood forest types more prominent in eastern South Dakota, such as sugarberry/hackberry /elm/green ash and elm/ash/locust, have more equal proportions in the younger (< 60 years) and older (> 60 years) age classes (Fig. 23). Aspen had a very high proportion of total volume in the younger age class, as did mixed upland hardwoods. What was striking was the similar number of cottonwood trees in young and older age classes. We would expect more young cottonwood trees than old ones, because younger trees suffer more intense competition-induced mortality.

What this means

Most older forests are located in the Black Hills region. Many of the younger stands in the Black Hills came into existence after natural (e.g., fire) or human-caused (e.g., harvesting or clearing) events.

The largely riparian nature of the forests outside of the Black Hills partially explains the relative youth of the forests in eastern South Dakota. Again, the relatively low number of young cottonwood trees suggest that the forest type is not replacing itself. Cottonwood relies upon disturbances, such as flooding, to bare soil to establish itself. The lack of flood-caused scouring and deposition events within the leveed major river systems provides limited opportunities to thrive without competition from other, more shade-tolerant hardwoods. Germination, in particular, requires a moist seedbed, such as found on streambanks. Bur oak forest types also appear to lack a preponderance of bur oak regeneration, a trend that could impact future wildlife populations dependent upon oak mast for food.

Figure 21.—Stand age of forested plots in South Dakota, 2005.

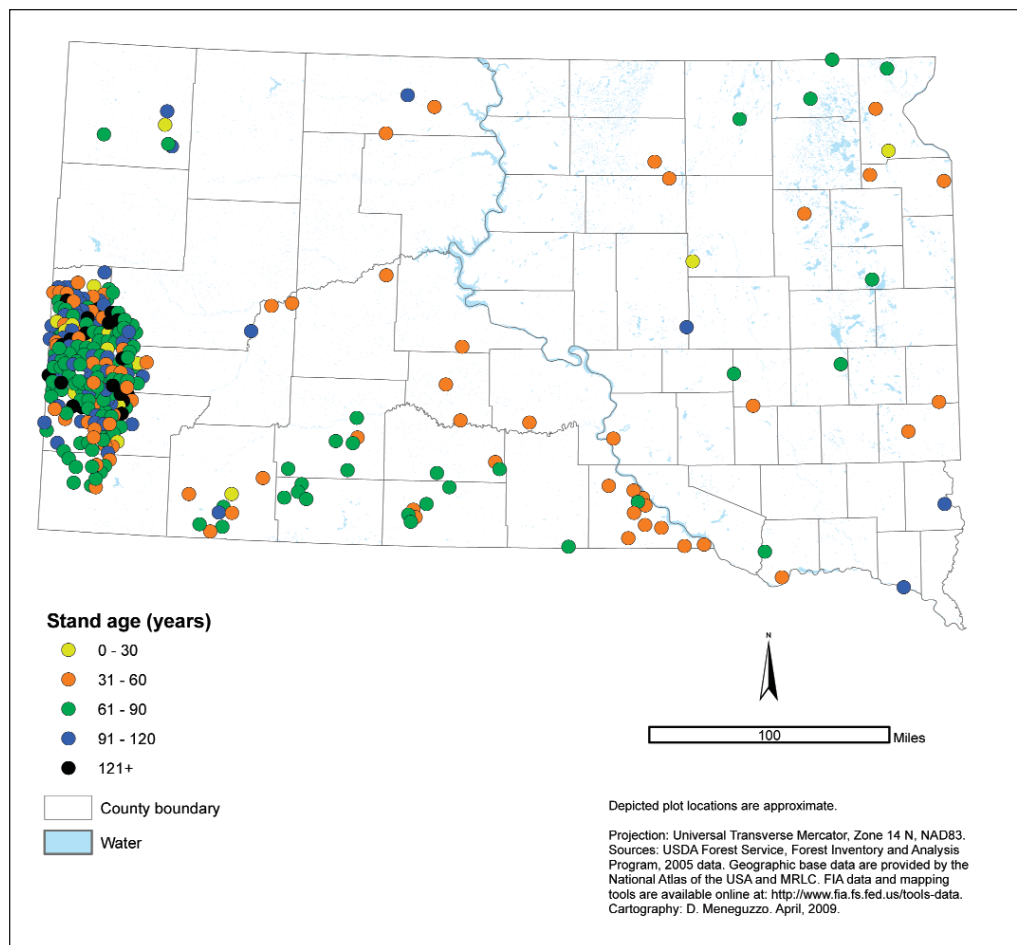


Figure 22.—Total volume and number of trees of all forest types and ponderosa pine forest type in South Dakota, 2005.

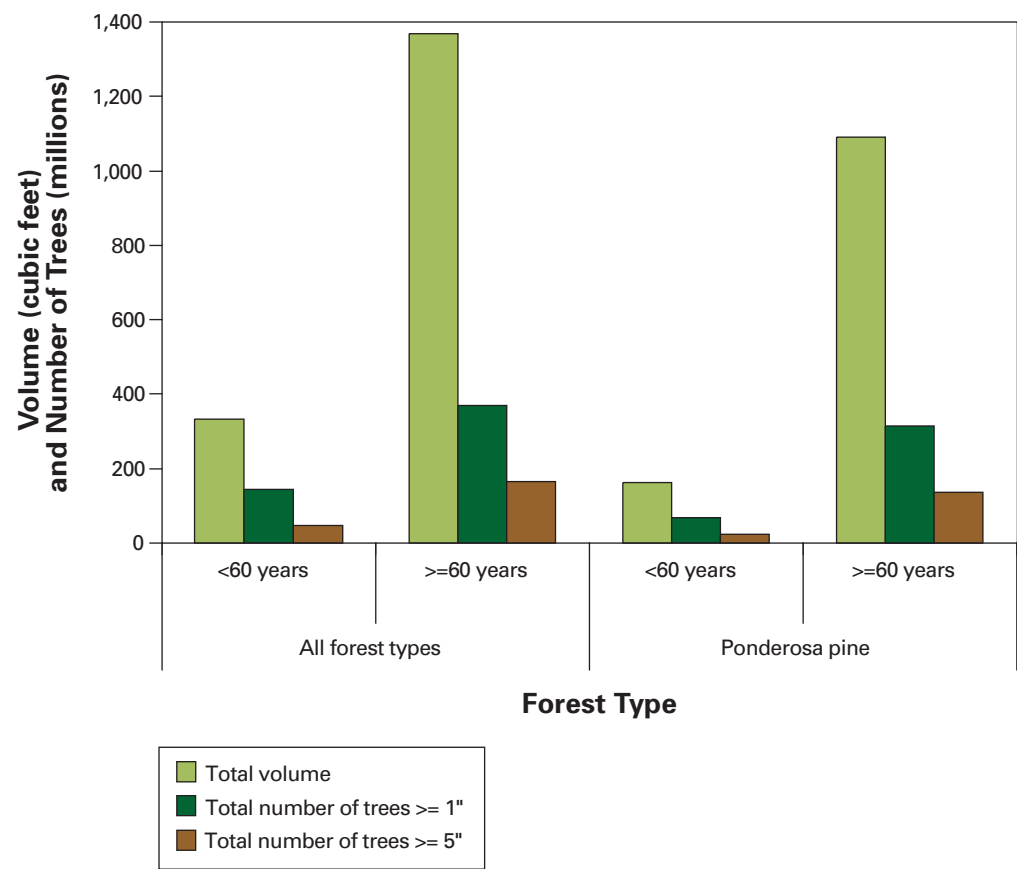
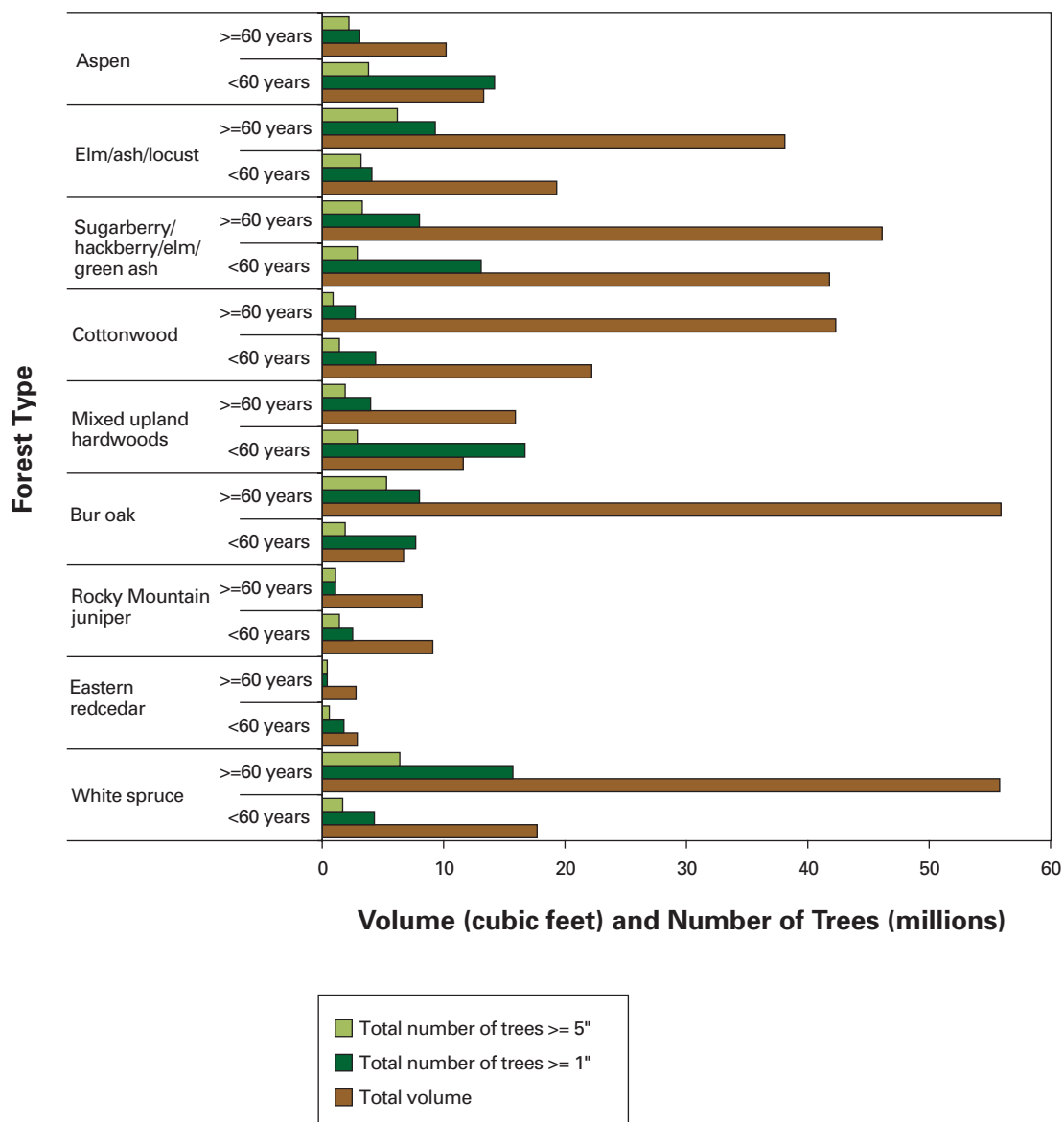


Figure 23.—Total volume and number of trees of selected forest types in South Dakota, 2005.



Stocking

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 help us assess the future growth or mortality of forest resources. Stand density may be a useful 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

Each acre of forest land in South Dakota supports an average of 304 live trees over 1 inch d.b.h. The mixed upland hardwoods forest type, with an average of 717 live trees per acre, had the greatest number of trees per acre (Fig. 24). The eastern redcedar had the lowest number of live trees per acre, with an average of 150. Nonstocked forest land averaged only 25 live trees over 1 inch d.b.h per acre. Both number of trees and stand-size class are important factors used to calculate cubic foot volume of wood per acre. The statewide average volume of live trees per acre of forest land is 1,288 cubic feet of wood per acre. The cottonwood forest type, which has most of its area in large-diameter stands, has the greatest average volume per acre at 1,717 cubic feet of wood per acre, even though it has one of the lowest averages for number of trees per acre.

Basal area – the cross sectional area of trees measured 4.5 feet above the ground – is another measure of stand density. Nearly 45 percent of the forest land in South Dakota had 80 square feet per acre or more (Fig. 25). More than 70 percent of the forest land in the Minnesota -Big Sioux-Coteau RBA had 80 square feet per acre or more. Only 17 percent of the White-Niobrara RBA's forest land had 80 square feet per acre or more.

What this means

A full range of forest stand density exists across South Dakota. Some factors leading to the low stocking levels are adverse site conditions (e.g., sites that receive low rainfall) that limit tree regeneration and growth. Other stands, such as 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. Overstocked stands are at increased risk of 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.

Figure 24.—Number of live forest land trees 1 inch or greater, area of forest land, 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, 2005.

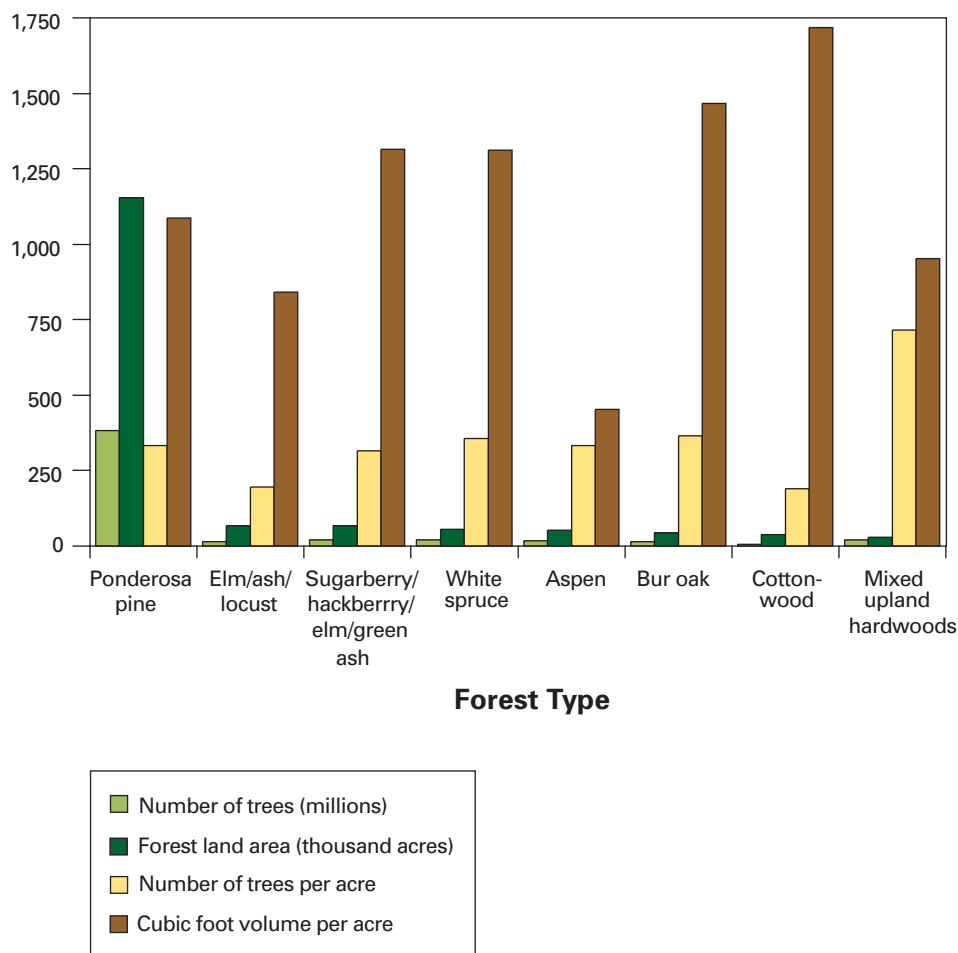
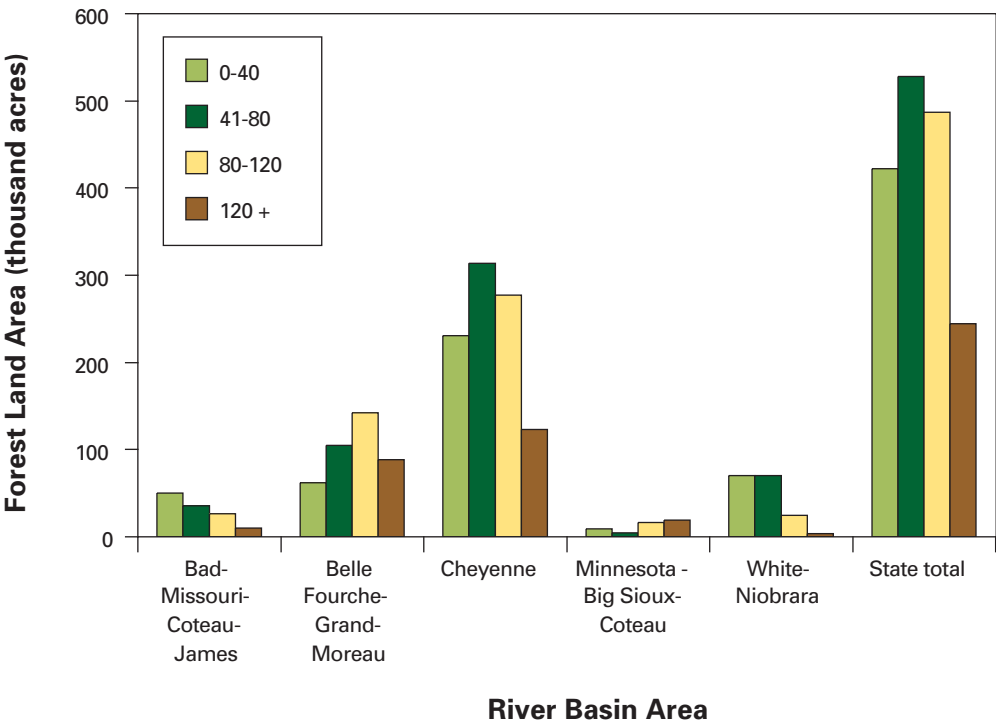


Figure 25.—Basal area (in square feet per acre) of forest land area by River Basin Area in South Dakota, 2005.



Biomass

Background

Tree biomass is the total dry weight of all live aboveground components of forest trees including boles, stumps, tops, and limbs. In commercial timber harvesting, the bole usually is the primary product because it contains wood used as lumber or veneer. Biomass estimates are increasingly important for carbon sequestration, fiber availability for fuel, and fuel loads analyses. As new industries emerge around the production of bio-based products (e.g., biocomposites and biofuels), residual biomass from forest thinning and timber harvest takes on added environmental and economic importance.

What we found

There was an estimated 45.7 million dry tons of total live aboveground tree biomass on forest land in South Dakota in 2005. The bole of trees 5.0 inches or greater accounts for 70 percent of the forest tree biomass (Fig. 26). Stumps, tops, and limbs account for another 24 percent and trees 1 inch to 4.9 inches d.b.h. account for the remaining 6 percent. Sixty-four percent of the total aboveground biomass is on forest land owned by the Forest Service (Fig. 27). Privately owned forest land contains another 28 percent of the total aboveground biomass.

Live, aboveground, softwood biomass is concentrated in western South Dakota, with the Belle Fourche-Grand-Moreau and Cheyenne RBAs containing 95 percent of the total live, aboveground, softwood biomass (Fig. 28). The live, aboveground, hardwood biomass is much more evenly distributed across the State.

What this means

In South Dakota, the average acre of forest had 27 dry tons of aboveground live-tree biomass. Forest land in State and local ownership had the highest total of all-live-tree biomass per acre with 31 dry tons of aboveground live-tree biomass per acre (Fig. 29). The State and local ownership did not have any forest land area that was classified as nonstocked, which would have lowered the average biomass per acre.

Because most forest biomass is in the trunks of trees, the management of South Dakota's forests strongly affects the dynamics of carbon storage and emission. When trees are cut, the decomposing slash and exposed soil can emit carbon (a source). Over time, the regrowing forest transitions from a source of carbon to a place that stores it (a sink). The products made from the harvested trees (e.g., lumber, paper, and posts) are sinks that store carbon. Other substantial pools of carbon are found in forest soils, standing and down dead trees, and nontree vegetation (live and dead).

Figure 26.—Distribution of components of live-tree biomass on forest land in South Dakota, 2005.

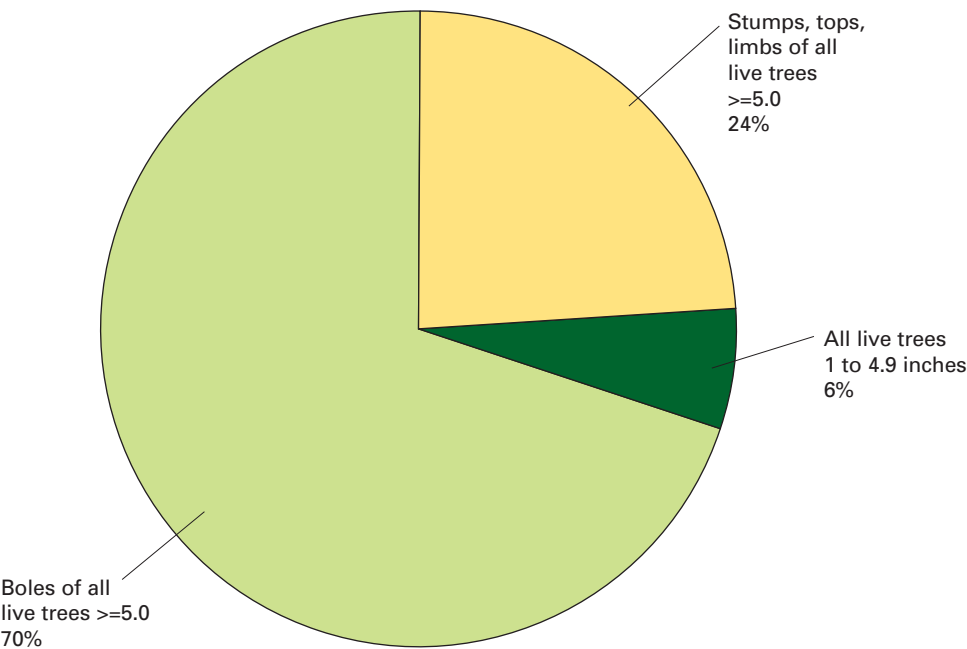


Figure 27.—Ownership of live-tree biomass on forest land in South Dakota, 2005.

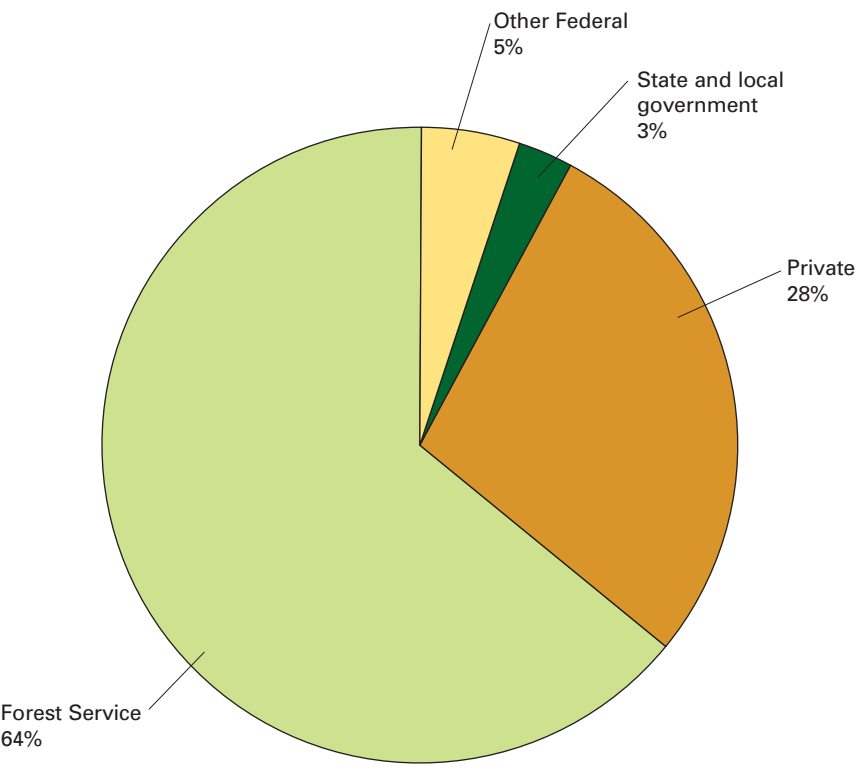


Figure 28.—Aboveground dry weight of all live-tree biomass by River Basin Area in South Dakota, 2005.

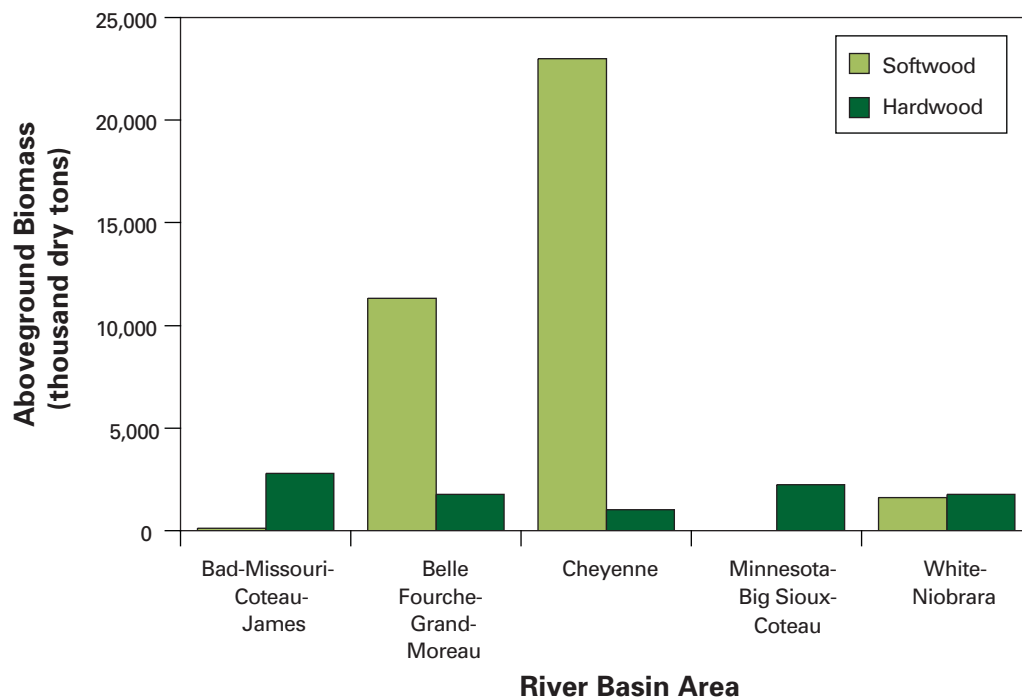
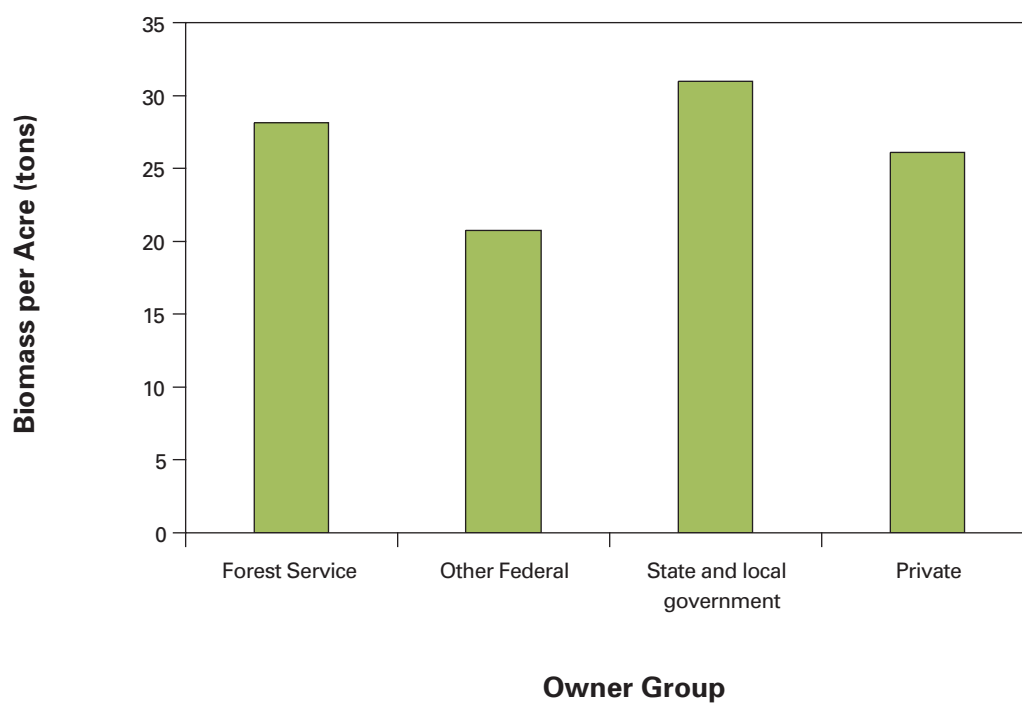


Figure 29.—Per acre aboveground dry weight of all live-tree biomass by owner group in South Dakota, 2005.



Forest Growth, Tree Mortality, and Forest Land Removals

Background

The capacity of forests to grow wood volume is an indicator of health, vigor, and development stage of trees in stands. Forest growth is expressed as average annual net growth, which is gross growth minus mortality. Mortality volume is the volume of wood in trees that have died from natural causes. Tree mortality is caused by factors such as disease, insect attack, physical damage, weather, and old age – often in combination. Removals volume is the volume of wood removed from stands through timber harvesting, cultural operations (e.g., timber stand improvement), land clearing, and changes in land use. Forest growth, tree mortality, and tree removals are computed by measuring trees at two points in time and determining the average annual change in volume over the period. Important note: Only trees from the 1999 inventory of the Black Hills National Forest were remeasured during the 2001-2005 annual inventory. Therefore, this section will pertain only to the area of the BHNF that is in South Dakota.

What we found

Every year between 1999 and 2005, there was an average of 41.6 million cubic feet of growing-stock volume added to the timberland of the BHNF in South Dakota through growth (average annual gross growth). From this average annual gross growth, an average of 14.6 million cubic feet of growing stock died each year (average annual mortality). This resulted in an average annual net growth of growing stock of 27.0 million cubic feet per year (Fig. 30). The average annual removal of growing stock during the same period was 13.5 million cubic feet. Subtracting mortality and removals from growth resulted in a net gain of 13.5 million cubic feet of growing stock per year between 1999 and 2005 on timberland in the BHNF in South Dakota.

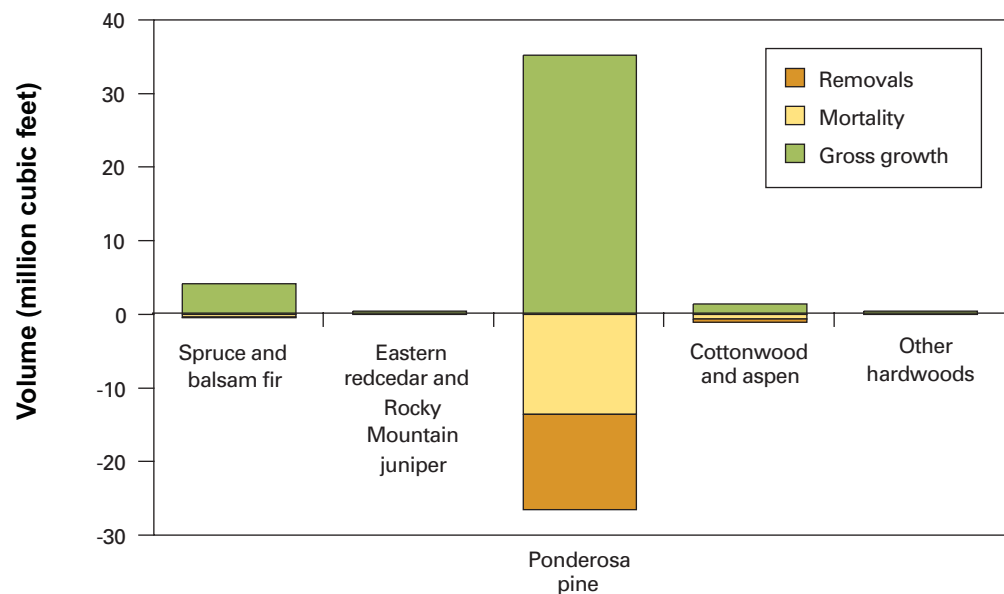
What this means

One measure of sustainability is the average annual net growth to average annual removals ratio (G/R). A number greater than 1.0 indicates the volume of the species is increasing. A number less than 1.0 indicates the volume is decreasing. Over all, the G/R for the BHNF in South Dakota from 1999 to 2005 was 2.0, indicating that average annual net growth is increasing twice as fast as removals. White spruce had a G/R of 38; only 10 percent of the gross growth was lost to mortality and another 2 percent was removed through harvesting, cultural operation, or land use conversion. The ponderosa pine and cottonwood/aspen species groups had a G/R of 1.8 and 1.6, respectively. Mortality and removals combined for both of these species groups was more than 75 percent of the gross growth. No species had a G/R of less than 1.0.

The overall G/R of 2.0 indicates there is room for more intensive management on the BHNF in South Dakota, especially for species besides the ponderosa pine and cottonwood/aspen species groups. At times, to achieve management goals, the G/R for a species may be less than 1.0. For example, when short-lived species such as aspen are nearing senescence, it may make sense to try to “capture mortality” by harvesting before the old trees die. This may bring the G/R below 1.0 for a short time as areas of older stands with larger volumes are replaced with younger stands of lower volume.

Of the three components of change (growth, mortality, and removals), removals is the most directly tied to human activity and is thus the most responsive to changing economic conditions.

Figure 30.—Average annual gross growth, average annual mortality, and average annual removals of growing-stock trees on timberland by species group on the Black Hills National Forest in South Dakota, 1999 to 2005.



Forest Health



Mortality from mountain pine beetle infestation. Photo used with permission by Blaine Cook, U.S. Forest Service.

Tree Crowns

Background

Tree crowns are an important component of net primary production on forest land. The overall condition of tree crowns may indicate the status of forest health. Large, dense crowns are associated with potential or previous vigorous growth rates. Small, sparse crowns suggest unfavorable site conditions such as overstocking, moisture stress, or poor soils. Forests suffering from a disease or insect epidemic, or damage from hail or ice storms, may have obvious dieback, low crown ratios, and high crown transparency.

What we found

The uncompacted live crown ratio is the percentage of a tree's height that supports live, green foliage that contributes to tree growth. White spruce and eastern redcedar had the highest mean crown ratio at more than 90 percent (Fig. 31). These species tend to have crowns that extend almost all the way to the ground. The mean uncompacted crown ratios for green ash and ponderosa pine were the lowest in the State, but they were still between 50 and 60 percent.

Dieback is an estimate of recent branch mortality in the upper and outer portions of the live crown. Quaking aspen, at almost 20 percent, had the highest average level of dieback. All of the remaining species measured had a dieback percentage of 5 percent or less.

Foliage transparency is the amount of skylight visible through the live, normally foliated portion of the crown. Quaking aspen, with the highest average level of crown dieback, also had the highest average foliage transparency, with a mean of almost 45 percent (moderate foliage transparency is 30 to 50 percent) (Fig. 32). Overall, the inventory found that 90 percent of the all trees measured had normal transparency (<30 percent).

What this means

Although crown conditions are sampled on a relatively small subset of forest inventory plots, the only health decline in crown conditions appeared with quaking aspen. Quaking aspen is a relatively short-lived species, and more than 45 percent of the aspen/birch forest type is more than 60 years old. The high percent of crown dieback and foliage transparency may be a sign that these stands are beginning to decline due to insect and disease problems associated with older aspen forests.

These baseline data are needed for analyzing crown health and for developing trends. Continued monitoring of crown health will help identify problems that may be harmful to the forest land of South Dakota. Conversely, improvements in crown health would indicate an improvement in overall forest health.

Figure 31.—Mean crown ratio and crown dieback by species in South Dakota, 2005.

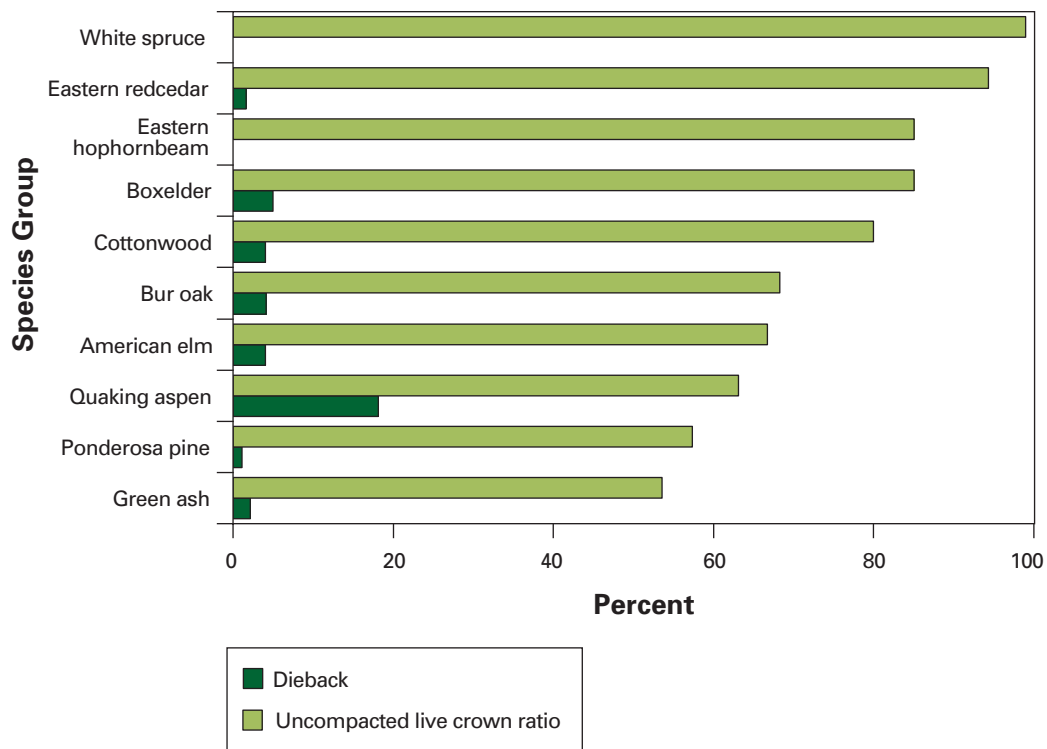
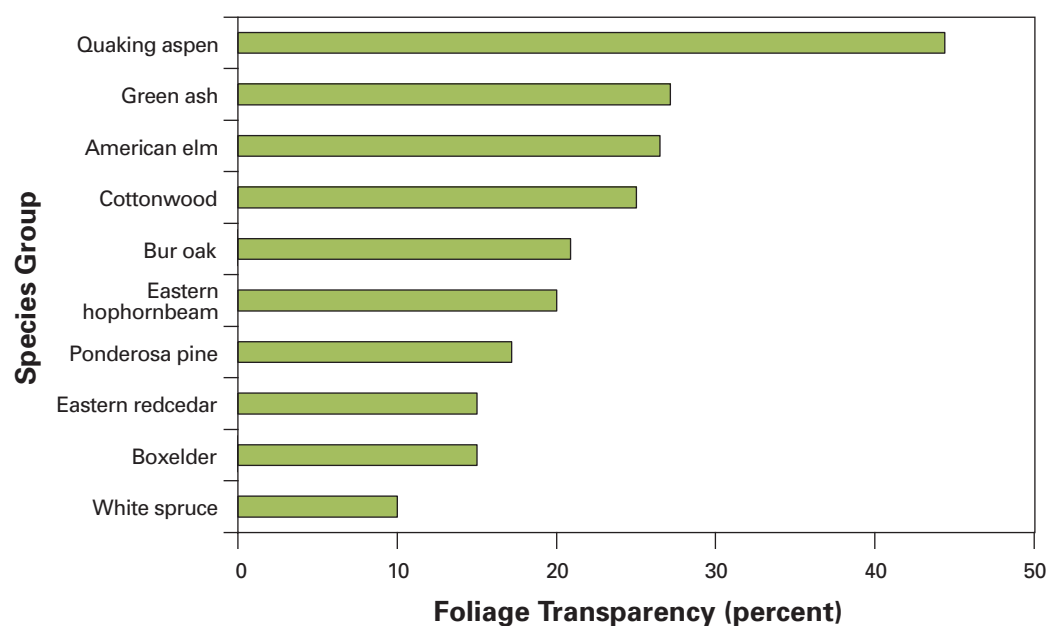


Figure 32.—Mean foliage transparency by species in South Dakota, 2005.



Down Woody Materials

Background

Down woody materials, in the form of fallen trees and branches, fill a critical ecological niche in South Dakota's forests. Down woody materials provide valuable wildlife habitat in the form of coarse woody debris and contribute toward forest fire hazards via surface woody fuels.

What we found

The fuel loadings of down woody materials (time-lag fuel classes) are not exceedingly high in South Dakota (Fig. 33). When compared to the neighboring states of North Dakota and Minnesota, South Dakota's total fuel loadings are not significantly different, except for a low amount of 1,000+-hr fuels (for time-lag definitions, see Woodall and Monleon 2008). The size-class distribution of coarse woody debris appears to be heavily skewed (76 percent) toward pieces less than 8 inches in diameter at point of intersection with plot sampling transects (Fig. 34). In decay class distribution of coarse woody debris, there appears to be a fairly uniform distribution of stages of coarse woody decay except for decay class 3 logs (51 percent) (Fig. 34). Decay class 3 coarse woody pieces are typified by moderately decayed logs that are still structurally sound but missing most of their bark and with extensive sapwood decay. Coarse woody debris volumes/acre appear to be almost uniform across classes of live tree density (basal area/acre) (Fig. 35).

What this means

The down woody fuel loadings in South Dakota's forests are not very different from those found in neighboring states. Therefore, only in times of extreme drought would these low amounts of fuels pose a hazard across the State. Of all down woody components, 1,000+-hr fuels made up the largest amounts. However, coarse woody debris volumes were still relatively low and were represented by small, moderately decayed pieces. This lack of coarse woody debris most likely also indicates a lack of wildlife habitat for some animal species.



Down wood material in ponderosa pine stand. Photo used with permission by Gregory Josten, South Dakota Department of Agriculture.

Overall, because fuel loadings are not exceedingly high across South Dakota, possible fire dangers are outweighed by the benefits of down woody material for wildlife habitat and carbon sinks.

Figure 33.—Mean fuel loadings (tons/acre, time-lag fuel classes) on forest land in South Dakota and neighboring states, 2005.

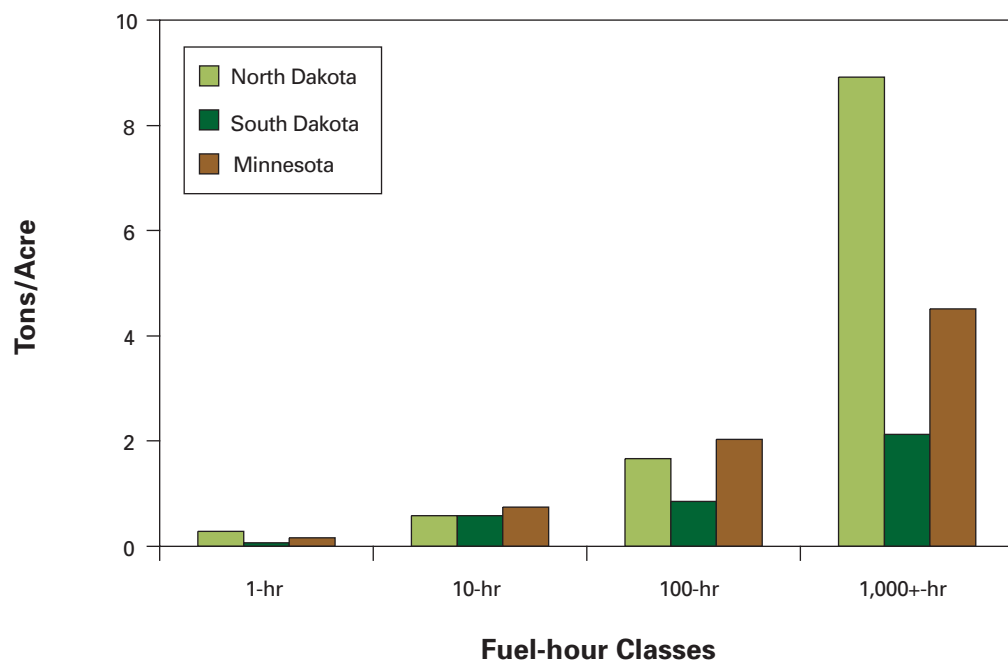
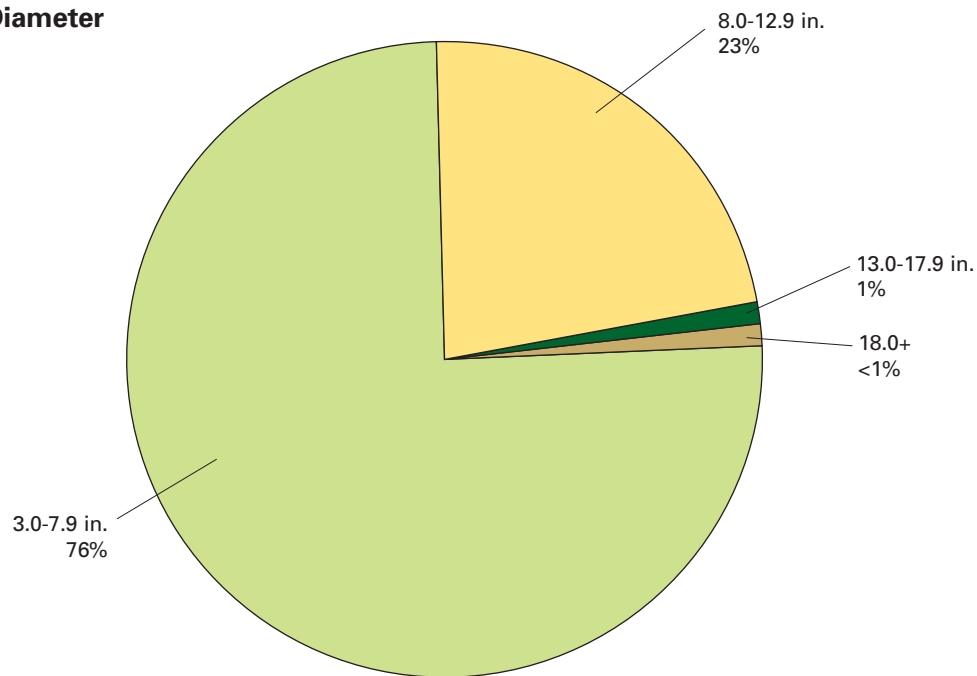


Figure 34.—Mean proportions of coarse woody debris total pieces per acre by transect diameter (inches) and decay classes on forest land in South Dakota, 2005.

Diameter



Decay Class

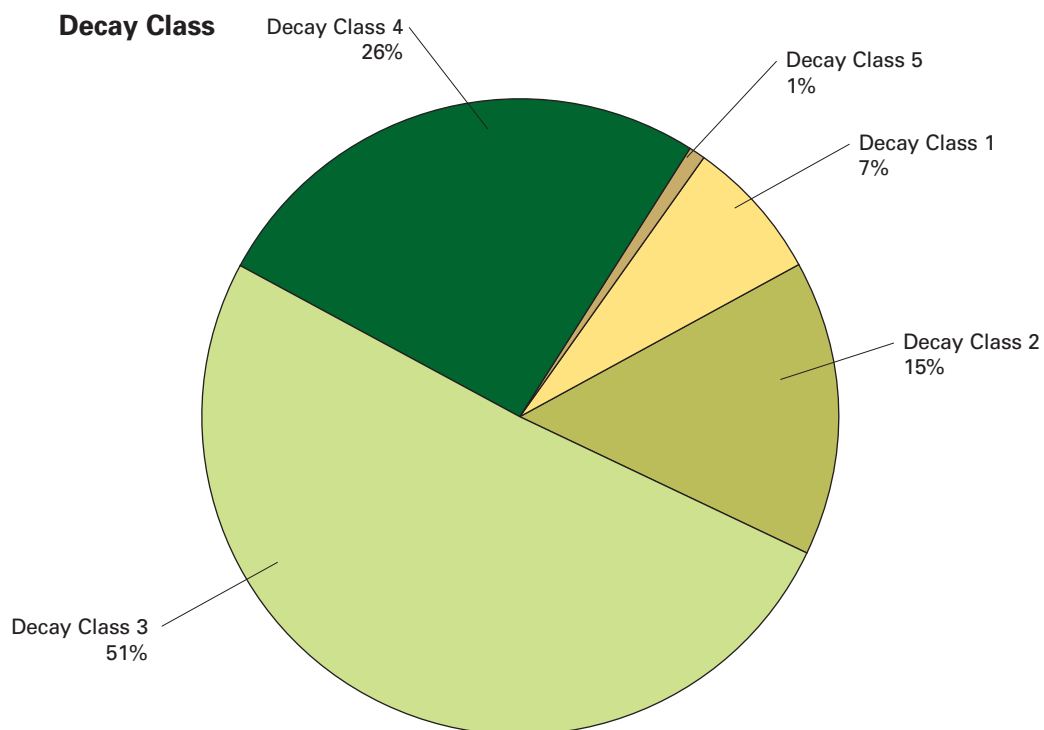
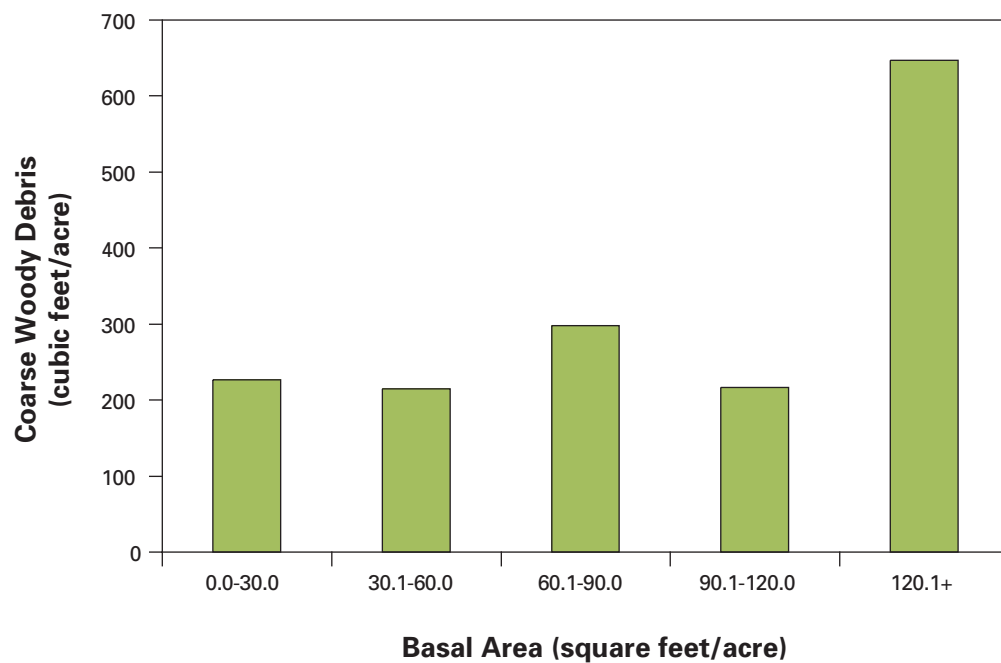


Figure 35.—Mean cubic foot volume of coarse woody debris per acre on forest land by basal area in South Dakota, 2005.



Ozone Damage

Background

Ozone found in the troposphere, the lowest layer of the atmosphere, is usually caused by air pollution from automobiles and power plants. Although ozone is mainly produced in metropolitan areas, it is transported via prevailing winds and, therefore, may show elevated levels far from its source. Besides impacting human health, high levels of ozone can harm agricultural crops and forest vegetation. The ozone biomonitoring program uses ozone-sensitive plants to monitor air quality and the potential impacts of tropospheric ozone (smog) on our Nation's forests.

What we found

Ozone bioindicator data were first collected in South Dakota in 2003. There were 12 biosites in both 2003 and 2004 and 13 biosites in 2005 where ozone-sensitive plants were evaluated for injury (Table 7). A total of 3,840 plants were evaluated over the 3-year period. None of the plants evaluated had any sign of ozone injury. The five ozone-sensitive bioindicator species that were measured in South Dakota include spreading dogbane, western wormwood, common and tall milkweed, green ash, ponderosa pine, and mountain snowberry.

What this means

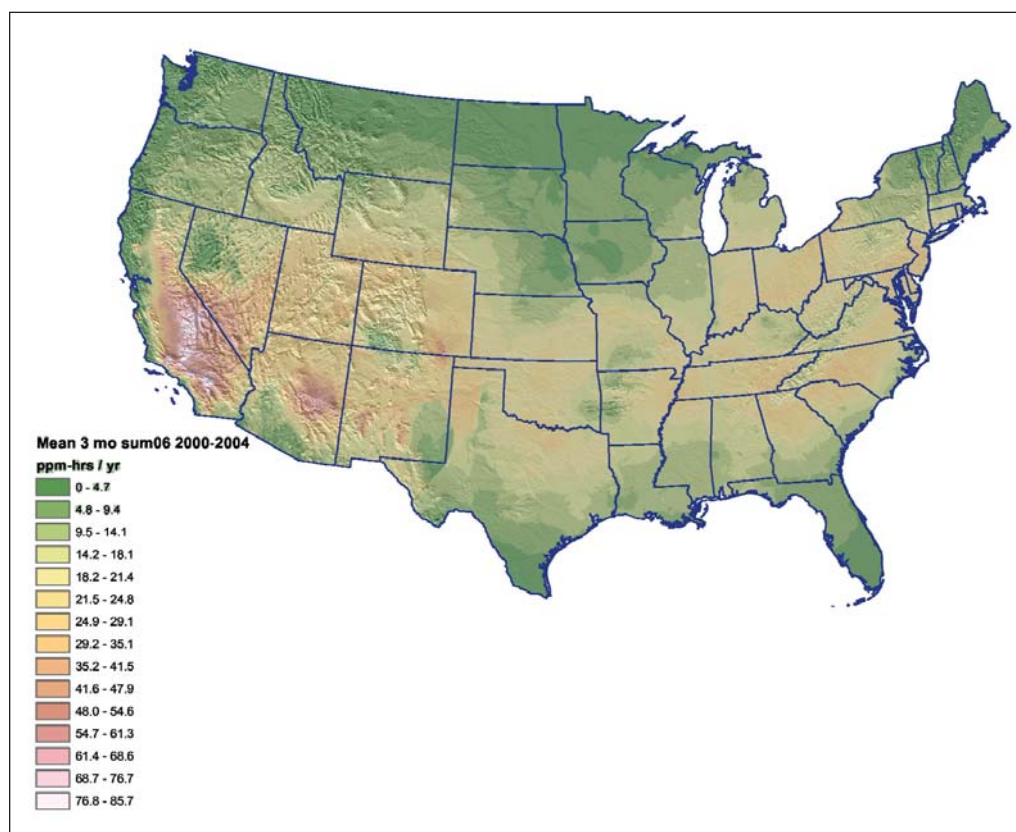
Ground level ozone is considered the most pervasive air pollutant worldwide and a serious threat to the conservation and sustainability of world forests. South Dakota's forests are exposed to relatively low levels of atmospheric ozone (Fig. 36). These exposures generally are not sufficient to result in observable or measurable adverse impacts. Consequently, the risk from ozone is considered low over most of the State.

The ozone biomonitoring sites established in South Dakota provide a baseline for the level of ozone-related injury to vegetation in the State. Future ozone biomonitoring will let us know if phytotoxic (plant damaging) concentrations of ozone are present in the forest ecosystem. We will also be able to monitor changes in the regional air quality (e.g., ozone pollution). These are just a couple of forest health assessment questions that are of interest to policymakers, forest managers, university researchers, and the general public.

Table 7.—Number of biosites and plants evaluated for ozone injury in South Dakota, 2003-2005.

Parameter	2003	2004	2005
Number of biosites by RBA			
Bad-Missouri-Coteau-James	4	4	4
Belle Fourche-Grand-Moreau	1	1	1
Cheyenne	4	4	4
Minnesota-Big Sioux-Coteau	1	1	2
White-Niobrara	2	2	2
Total	12	12	13
Biosites with injury	0	0	0
Number of plants evaluated	1,264	1,170	1,406
Number of plants with injury	0	0	0
Average number of species/biosite	3.9	4.2	3.7

Figure 36.—Spatial interpolation of mean 3-month (June, July, August) cumulative ozone concentrations (SUM 06) for the continental United States, 2000 to 2004. SUM06 is defined as the sum of hourly ozone concentrations ≥ 0.06 ppm. Descriptive ozone exposure categories based on mean values are as follows: clean (0-10 ppm-hrs), low (>10-20 ppm-hrs), moderate (>20-30 ppm-hrs), and high (>30 ppm-hrs) ozone exposure.



Forest Soils

Background

Rich soils are the foundation of productive forest land. Inventory and assessment of the forest soil resource provide critical baseline information on forest health and productivity, especially in the face of continued natural and human disturbance.

What we found

Field data are available from 2001 to 2004. Most of the sample locations in South Dakota are located in ponderosa pine forests, but we can make some very broad generalizations using data from other Plains States (North Dakota, Nebraska, and Kansas). Forest floor accumulations under South Dakota's ponderosa pine forests are greater than those observed in neighboring states (Fig. 37). The same is true of the single pinyon/juniper and elm/ash/cottonwood forest type observations. The one measurement in the mixed upland hardwoods forest type is above the median value.

Soil carbon content in the forest floor and mineral soil was calculated from laboratory measurements. The forest floor under South Dakota's forests stores as much or more carbon than that in neighboring states, both within and across forest-type groups (Fig. 38). The same is true in the 0- to 10-cm layer of mineral soil (Fig. 39). In the 10- to 20-cm layer, carbon storage is more consistent across the region. Interestingly, the thick forest floor under the elm/ash/cottonwood is not especially rich in carbon. No mineral soil sample was collected in elm/ash/cottonwood in South Dakota.

The Soil Quality Index (SQI) is a new measure designed to combine the distinct physical and chemical properties of the soil into a single, integrative assessment (Amacher et al. 2007). SQI values in South Dakota fall generally around the mean value of observations in the Plains States (Fig. 40). A few sites had below average soil quality resulting from several factors: low carbon and nitrogen content, high soil pH, and a large volume of coarse fragments.

What this means

Soil carbon is significant for several reasons. First, carbon is the primary component of soil organic matter, which has a number of important functions. These include increasing water holding capacity, retaining some nutrients by cation exchange (e.g., Ca^{2+} , Mg^{2+} , K^{+}), releasing other nutrients as it decays (e.g., nitrogen, phosphorus, and sulfur), and capturing potential toxic agents (e.g., mercury) (McBride 1994). Nationally and internationally, carbon is also inventoried to track the sequestration of certain greenhouse gases.

Nitrogen, an essential element for plant growth, affects a plant's composition more than any other mineral nutrient (Marschner 1986). It is essential for building proteins, and growth is inhibited when nitrogen levels are suboptimal. Soil pH is the “master variable” controlling

many of the critical chemical processes in soils (McBride 1994). High pH levels are linked with reduced availability of specific cations such as Zn^{2+} (McBride 1994). Excessive coarse fragments reduce the rooting volume of the soil and thus limit a plant's access to water and essential minerals.

The soil indicator is in its infancy, but the data suggest that while the forest soils of South Dakota are similar to other soils in the region, they are storing above average amounts of carbon. This is particularly true in the ponderosa pine forest-type group; these forests may play an important role in future sequestration programs. Conversely, if fire suppression is replaced with a historically more natural fire regime, this will lead to a thinner forest floor and a lower average amount of forest floor carbon storage.

Figure 37.—Observations of forest floor thickness in South Dakota and other Plains States, 2001-2004.

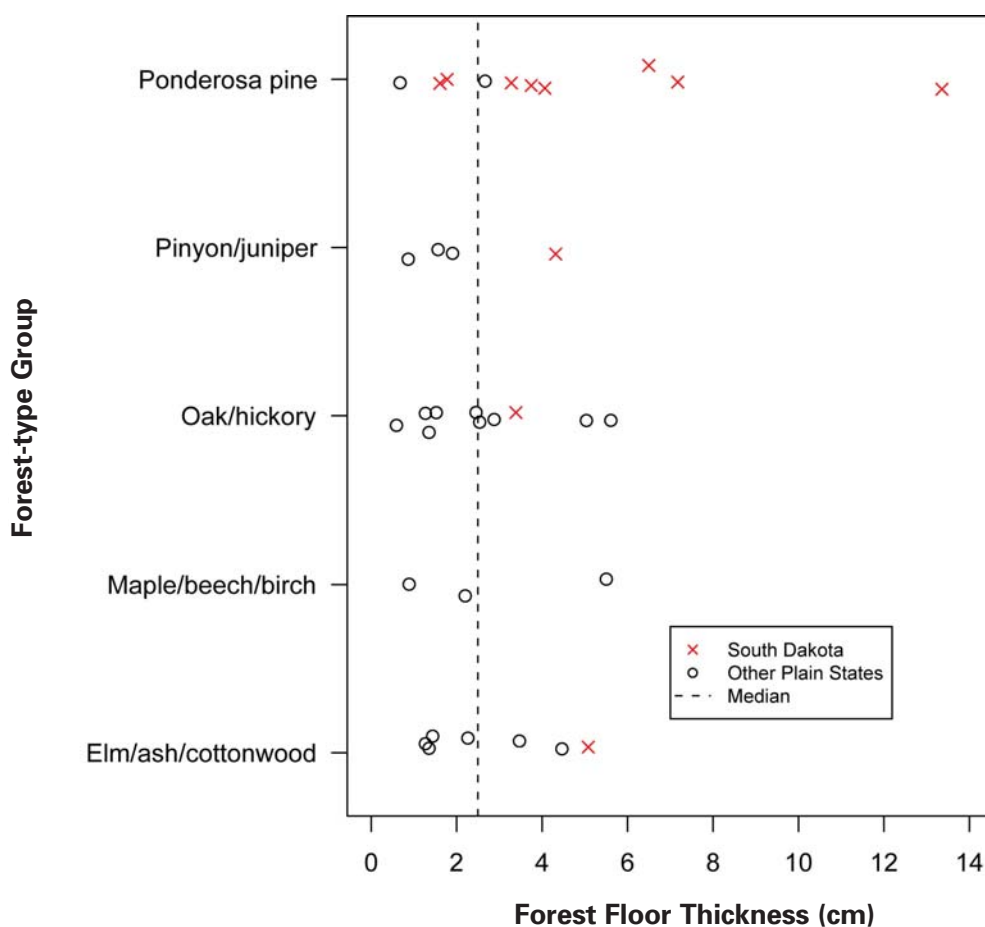


Figure 38.—Observations of forest floor soil carbon content in South Dakota and other Plains States, 2001-2004.

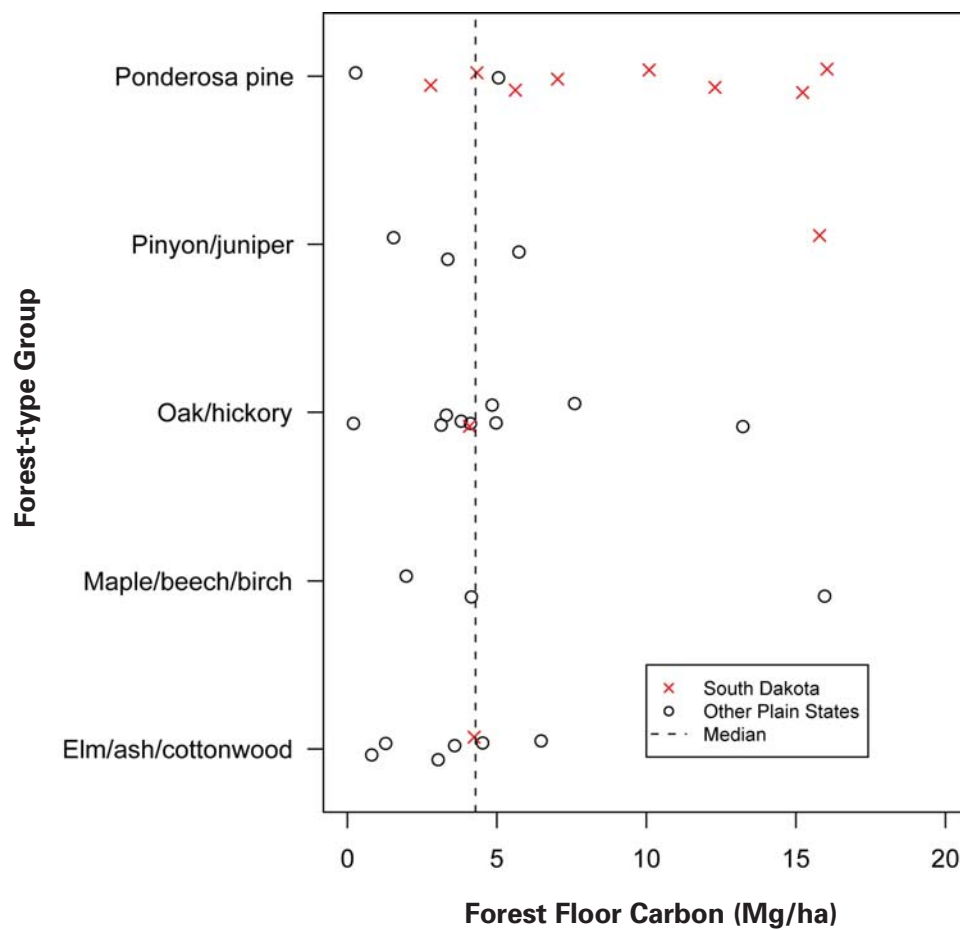


Figure 39.—Observations of mineral soil carbon content, 0-10 cm in South Dakota and other Plains States, 2001-2004.

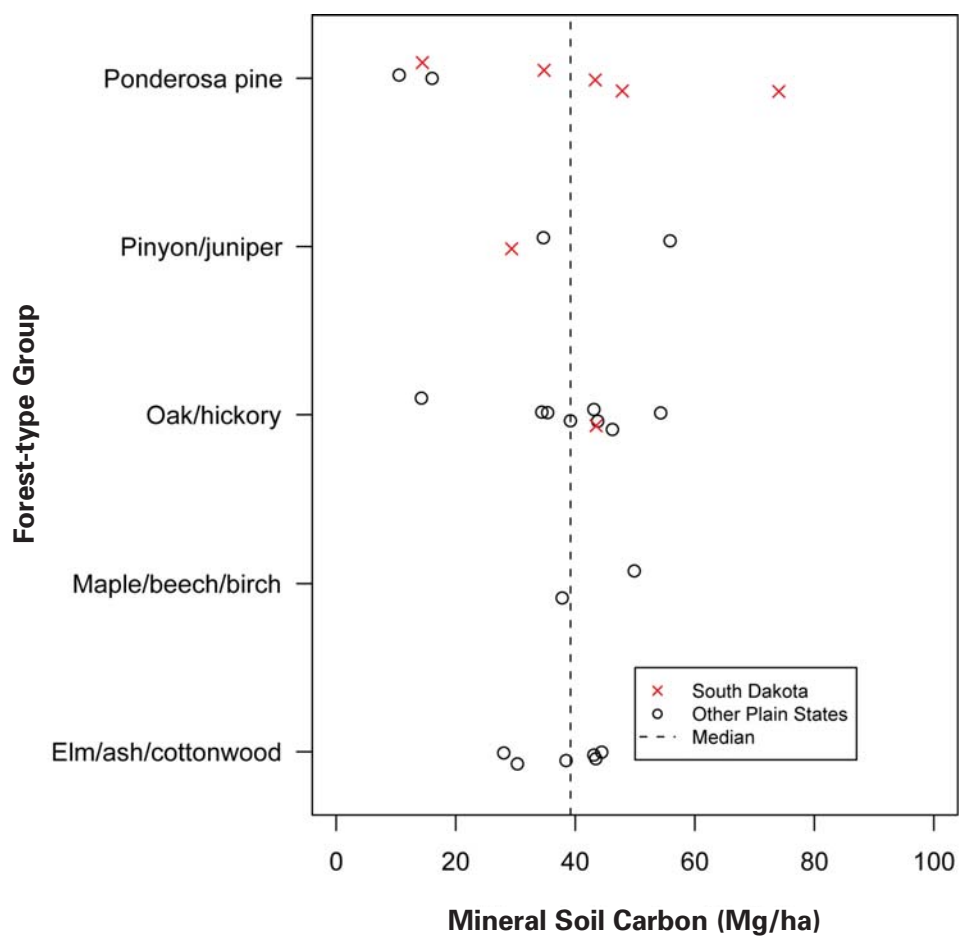
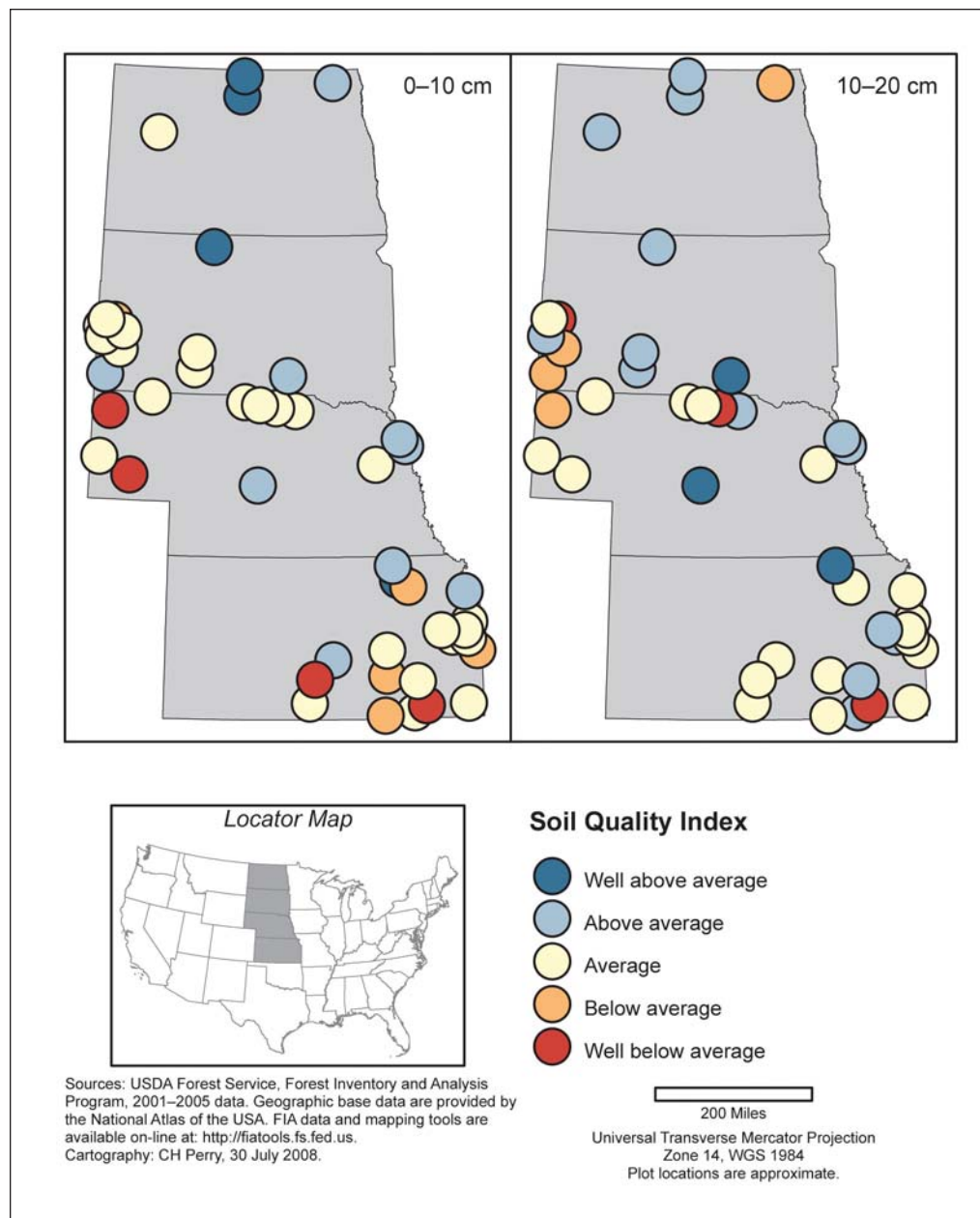


Figure 40.—The Soil Quality Index (Amacher et al. 2007) highlights differences in the overall chemical and physical condition of the soil in South Dakota and other Plains States, 2001–2004.



Forest Insects and Diseases

Background

During the past decades, native and non-native insects and diseases have had a large impact on the structure, diversity, and health of South Dakota's forests. Insects and diseases often cause damage when forests are affected by abiotic stressors such as drought and storm damage. Monitoring insects and diseases in the context of abiotic agents is crucial to predicting and managing South Dakota's future forest resources.

What we found

Several forest insects and diseases have been identified that adversely affect the health of South Dakota's forests (Table 8). Among those that have the greatest effect are mountain pine beetle, pine engraver beetle, diplodia blight, and Dutch elm disease. Trees that are already stressed by drought conditions and/or damaged by snow storms, ice damage, or hail, are most susceptible to attack. The two-lined chestnut borer, banded elm bark beetle, and white pine blister rust are causing localized problems.

What this means

Insect and disease affected forest land across South Dakota during the inventory period with varying degrees of severity. Some of these impacts were local or regional and confined to a single year, while others were statewide and ongoing. Infestations of the native mountain pine beetle are cyclical. The current outbreak, which began in the late 1990s, remains at epidemic levels. The introduction of the banded elm bark beetle is of concern because when the beetles are found in elms with Dutch elm disease, they may be able to spread the disease to other American elm trees. In the Black Hills, white pine blister rust is occurring in the only existing stand of limber pine in South Dakota, which is now limited to only a couple hundred trees. This stand has been treated to remove competition with encroaching ponderosa pine and Black Hills spruce. Pine tip moth, pine wilt, pinewood nematode, and Zimmerman pine moth primarily affect windbreaks, plantations, and ornamental trees. Insect and disease monitoring will remain important for early detection and eradication/control of these forest pests. For example, thousands of traps were used for early gypsy moth detection in Colorado, Kansas, Nebraska, South Dakota, and Wyoming. Only a few adult moths were found in South Dakota in 2002 and 2004, but no insect larvae or pupae were found on trees, nor has any defoliation been attributed to gypsy moth.

Table 8.—Insects and diseases affecting South Dakota forests, 2001-2005. (Adapted from U.S. Department of Agriculture, 2003a, 2003b, 2004, 2005, 2006)

2001	2002	2003	2004	2005	Host(s)
Insects – native					
Mountain pine beetle	Mountain pine beetle	Mountain pine beetle	Mountain pine beetle	Mountain pine beetle	Ponderosa pine
Pine engraver beetle	Pine engraver beetle	Pine engraver beetle	Pine engraver beetle	Pine engraver beetle	Ponderosa pine
Red turpentine beetle	Red turpentine beetle				Ponderosa pine
		Zimmerman pine moth	Zimmerman pine moth	Zimmerman pine moth	Austrian, ponderosa, Scots pines, and Colorado blue spruce
				Two-lined chestnut borer	Bur oak
				Pine sawfly	Ponderosa pine
				Pine tip moth	Austrian, ponderosa, Scots pines
Insects – non-native					
	Gypsy moth		Gypsy moth		Hardwoods
		Banded elm bark beetle	Banded elm bark beetle	Banded elm bark beetle	American and Siberian elms
Disease – native					
Armillaria root disease	Armillaria root disease	Armillaria root disease	Armillaria root disease	Armillaria root disease	Hardwoods and softwoods
Diplodia blight	Diplodia blight	Diplodia blight	Diplodia blight	Diplodia blight	Austrian, ponderosa, Scots pines
Pine wilt and pinewood nematode	Pine wilt and pinewood nematode	Pine wilt and pinewood nematode	Pine wilt and pinewood nematode	Pine wilt and pinewood nematode	Austrian, ponderosa, Scots pines
				Cytospora and Hypoxylon canker	Alders and aspens
				Western gall rust	Ponderosa pine
Disease – non-native					
Dutch elm disease	Dutch elm disease	Dutch elm disease	Dutch elm disease	Dutch elm disease	American elm
White pine blister rust	White pine blister rust	White pine blister rust	White pine blister rust	White pine blister rust	Limber pine

Emerald Ash Borer

Background

Discovered in southeastern Michigan in 2002, the emerald ash borer (EAB) is an exotic wood-boring beetle that has quickly become a significant threat to the North American ash resource. EAB is a pest of all major species of ash, including green, white, black, and blue ash, and all ash cultivars (Cappaert et al. 2005). EAB has killed many ashes in the central portion of the U.S., but at the time of this report, it had not been found in South Dakota.

What we found

Green ash is a commonly observed species throughout South Dakota. High densities of green ash are found in the south-central, northeastern, and southwestern portions of the State (Fig. 41). With an estimated 18.5 million trees greater than 1 inch in diameter (nearly 4 percent of total live trees), green ash is the sixth most abundant tree in South Dakota's forests by number of trees and is ranked fourth by estimate of total volume. The total live volume of green ash is 72.1 million cubic feet, or 4 percent of the total volume on forest land. Green ash occurs on 185,200 acres, or 11 percent of forest land (Fig. 42). When present in a stand, green ash generally represents more than 25 percent of the total live-tree basal area. Although green ash is found on a range of physiographic conditions, 39 percent of green ash trees are in floodplain or riparian forests (Fig. 43).

What this means

Since its discovery, EAB has caused substantial ash decline and mortality in the north-central portion of the U.S. Human transportation of infested ash material has been the primary mechanism of EAB dispersal and has increased the risk of EAB introduction to new areas. In addition to the risk posed by human transport, the abundance of ash across the South Dakota landscape makes EAB a major threat to statewide forest resources. The introduction of EAB would not only impact the structure and composition of South



Emerald ash borer. Photo used with permission from the Pennsylvania Department of Conservation and Natural Resources, www.forestryimages.org.

Dakota's woodland and riparian forests, it would also cause significant economic losses to forestry-related industries, including timber, wood products, nurseries, and recreation.

Green ash is also an important component of South Dakota's urban forests. Community forest inventories have shown it to be the most

common street tree, making up more than 35 percent of the total street tree population in the State. Thus, EAB could potentially have a huge impact on the urban forest of South Dakota.

State forestry agencies in Kansas, Nebraska, North Dakota, and South Dakota are taking part in a regional initiative to prepare for the arrival of invasive pests, such as EAB, that threaten tree resources in the northern plains. The Great Plains Tree and Forest Invasives Initiative (Great Plains Initiative) gives state forestry agencies the opportunity to work together to create public awareness, promote alternatives to ash tree plantings, and prepare for EAB's arrival by assessing the region's tree resources and determining and addressing the potential impacts of EAB to those resources.

Figure 41.—Number of ash trees per acre on forest land, South Dakota, 2005.

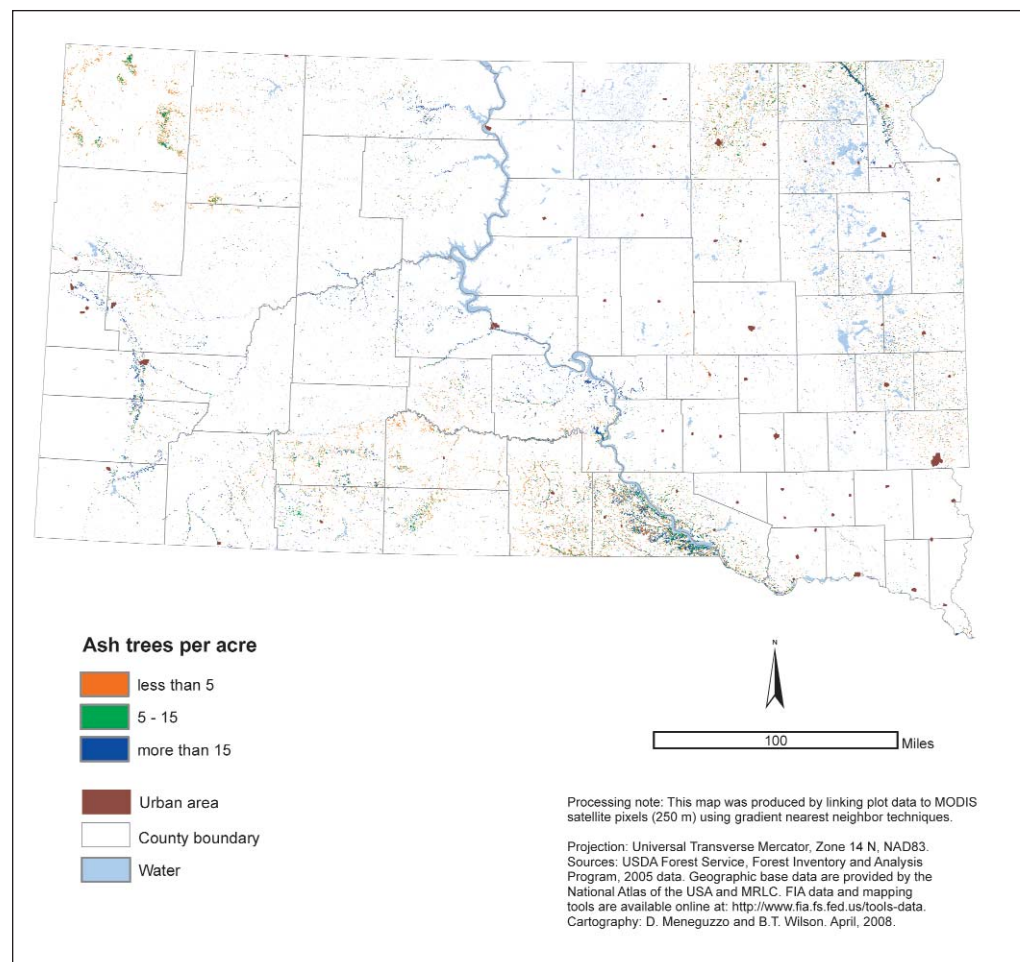


Figure 42.—Presence of ash on forest land, expressed as a percentage of stand basal area (ash BA per acre/total live BA per acre), South Dakota, 2005.

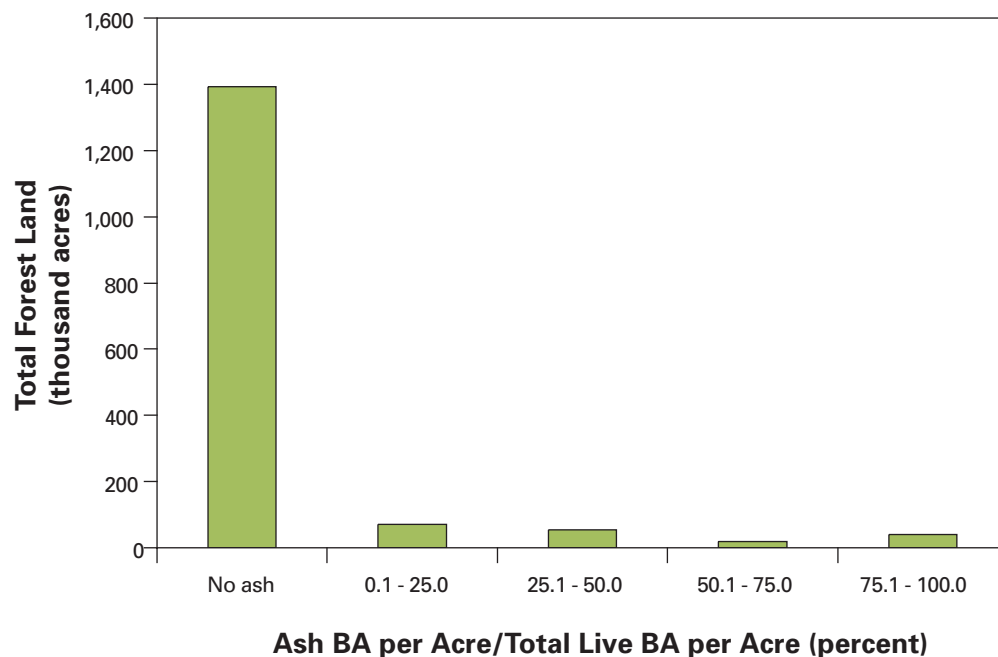
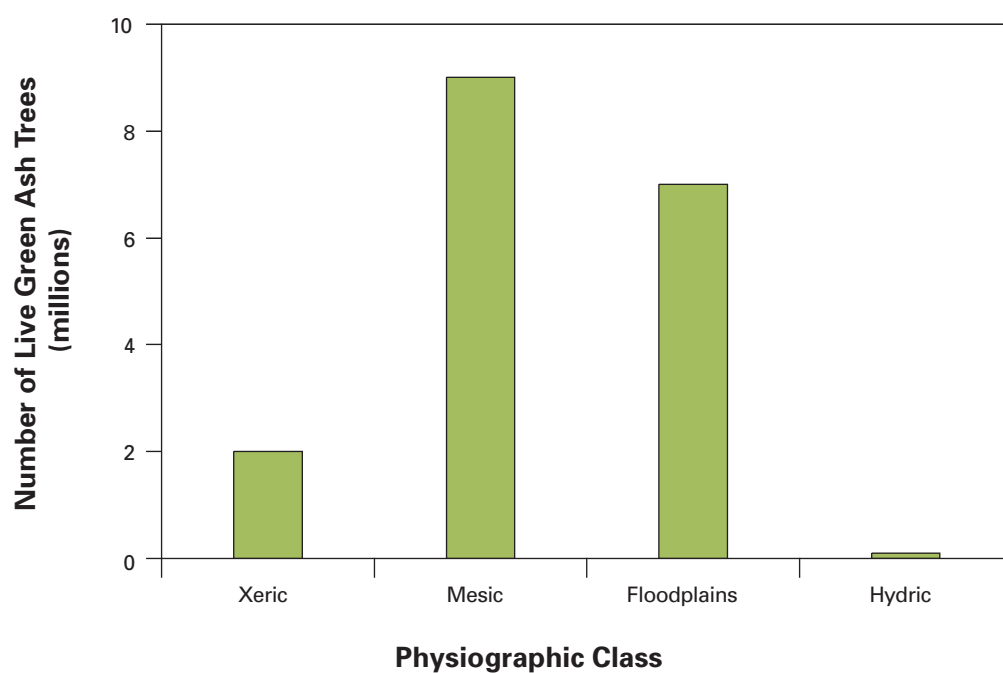


Figure 43.—Number of live green ash trees on forest land by physiographic class, South Dakota, 2005.



Forest Invaders Non-native Plants

Background

Non-native invasive plant species threaten ecosystems across our country and South Dakota is at risk. Invasive species reduce ecosystem diversity and wildlife habitat by displacing native plants. During the 2005 field season, all of the 72 forested Phase 2 plots (P2) were assessed for presence and cover of any of 25 non-native invasive species (Table 9). If a species on the list was found, the percent cover was estimated and placed into one of seven codes, ranging from 1 (trace) to 7 (76 to 100 percent) (Table 10). If a non-native invasive plant species was found that had not been previously documented to exist in the State, a specimen was collected and sent to St. Paul for positive identification.

What we found

On 7 of the 72 plots sampled in 2005, there were seven occurrences of three non-native invasive plant species (Table 11). Common buckthorn, a woody species, was the most prominent of the invasive species and was found on hardwood plots in eastern South Dakota.

What this means

Invasive species can be found in most of the State's forests. However, their negative effect on forest health is not always easy to measure. For example, even though common buckthorn occurred on only five plots, where it does occur it tends to completely dominate the forest understory, making it impossible for native plants to thrive. Non-native invasive plants generally outcompete native plants by aggressively monopolizing light, water, nutrients, and space. They are a particular threat to those species that complete their life cycles in the spring. Leafy spurge, a common rangeland invasive, is likely more common in the State than we have documented, because it thrives on landscapes that do not qualify as forest under FIA definitions.

Although not on the list of non-native invasive plants that were inventoried, saltcedar (*Tamarix* spp.) has become a problem in South Dakota and has been declared a noxious



Common buckthorn. Courtesy of Paul Wray, Iowa State University, Bugwood.org.

weed. Most of the infested areas would probably not show up as forest land under the FIA definition, but rather would be nonforest land with trees. In 2007, this species plus 17 others were added to the list of non-native invasive plants that FIA will inventory.

Table 9.—Non-native invasive plants inventoried on NRS-FIA Phase 2 plots in the Upper Midwest, 2005.

COMMON NAME	SCIENTIFIC NAME
Woody species	
Multiflora rose	<i>Rosa multiflora</i>
Japanese barberry	<i>Berberis thunbergii</i>
Common buckthorn	<i>Rhamnus cathartica</i>
Glossy buckthorn	<i>Frangula alnus</i>
Autumn olive	<i>Elaeagnus umbellata</i>
Non-native bush honeysuckles	<i>Lonicera</i> spp.
European privet	<i>Ligustrum vulgare</i>
Vines	
Kudzu	<i>Pueraria Montana</i>
Porcelain berry	<i>Ampelopsis brevipedunculata</i>
Asian bittersweet	<i>Celastrus orbiculatus</i>
Japanese honeysuckle	<i>Lonicera japonica</i>
Chinese yam	<i>Dioscorea oppositifolia</i>
Black swallowwort	<i>Cynanchum louiseae</i>
Wintercreeper	<i>Euonymus fortunei</i>
Grasses	
Reed canary grass	<i>Phalaris arundinacea</i>
Phragmites, common reed	<i>Phragmites australis</i>
Nepalese browntop, Japanese stiltgrass	<i>Microstegium vimineum</i>
Herbaceous	
Garlic mustard	<i>Alliaria petiolata</i>
Leafy spurge	<i>Euphorbia esula</i>
Spotted knapweed	<i>Centaurea biebersteinii</i>
Dame's rocket	<i>Hesperis matronalis</i>
Mile-a-minute weed, Asiatic tearthumb	<i>Polygonum perfoliatum</i>
Common burdock	<i>Arctium minus</i>
Japanese knotweed	<i>Polygonum cuspidatum</i>
Marsh thistle	<i>Cirsium palustre</i>

Table 10.—Cover codes and ranges of percent cover of non-native invasive plants used in recording the presence of invasive species, NRS-FIA Phase 2 plots in the Upper Midwest, 2005.

Cover code	Range of percent cover
1	< 1, trace
2	1 to 5
3	6 to 10
4	11 to 25
5	26 to 50
6	51 to 75
7	76 to 100

Table 11.—Occurrences of prominent non-native invasive plants, by percent cover and forest type, found on NRS-FIA Phase 2 plots in South Dakota, 2005 panel only.

Forest type	Percent cover of common buckthorn	Percent cover of leafy spurge	Percent cover of common burdock
Ponderosa pine		1-5	
Elm/ash/locust	1-5, 11-25, 76-100		
Cottonwood	1-5		
Sugarberry/hackberry/elm/green ash			26-50
Unknown	26-50		

Forest Products



Timber harvest in the Black Hills. Photo used with permission by Gregory Josten, South Dakota Department of Agriculture.

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 are 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

Following a 2-percent decrease in total growing-stock volume between 1984 and 1996, total growing-stock volume increased by 5 percent between the 1996 inventory and the 2005 inventory. Between the two inventories, hardwood growing-stock volume increased by 20 percent and softwood growing-stock volume increased by 3 percent (Fig. 44).

The volume of growing stock on timberland increased by almost 80 percent in the Bad-Missouri-Coteau-James RBA, increased by 66 percent in the White-Niobrara RBA, and increased by 30 percent in the Belle Fourche-Grand-Moreau RBA (Fig. 45). The growing stock on timberland decreased by 8 percent in the Cheyenne RBA and decreased by 20 percent in Minnesota-Big Sioux-Coteau RBA. Despite the decrease of growing-stock volume in the Cheyenne RBA, it still contained 56 percent of the State's total growing-stock volume.

Growing-stock volume of eastern redcedar increased by more than 350 percent between 1996 and 2005, from 1 million cubic feet in 1996 to 6 million cubic feet in 2005 (Fig. 46). Other species groups that had large increases were bur oak with an 89-percent increase, green ash with a 74-percent increase, and elms with a 71-percent increase. Paper birch, maples, and other hardwoods species groups were the big losers with a decrease in growing-stock volume of 17 percent, 19 percent, and 43 percent, respectively.

What this means

South Dakota's forests supply much of the wood for the State's timber products industry. However, the industry could be adversely affected if mortality due to fires, insects, or other forest health issues increased. The species composition of the State's forest land is changing as eastern redcedar encroaches into many of the forest types. Overall volumes and areas of hardwoods are also increasing.

Figure 44.—Growing-stock volume on timberland by hardwoods and softwoods, and inventory year in South Dakota.

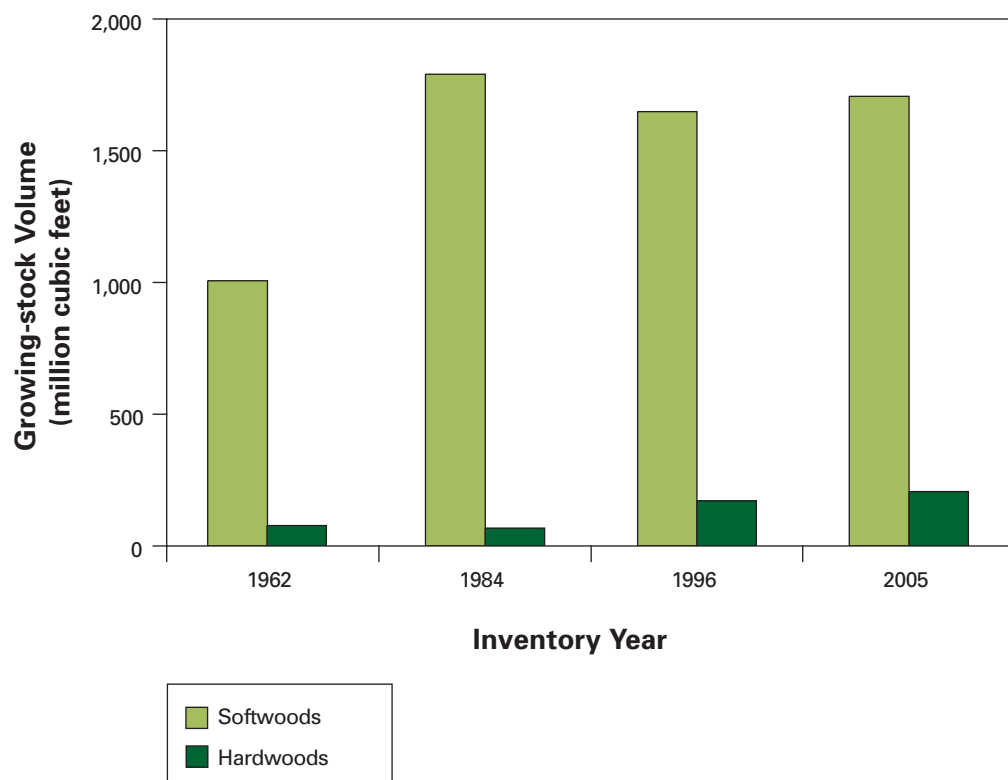


Figure 45.—Growing-stock volume on timberland by River Basin Area in South Dakota, 1996 and 2005.

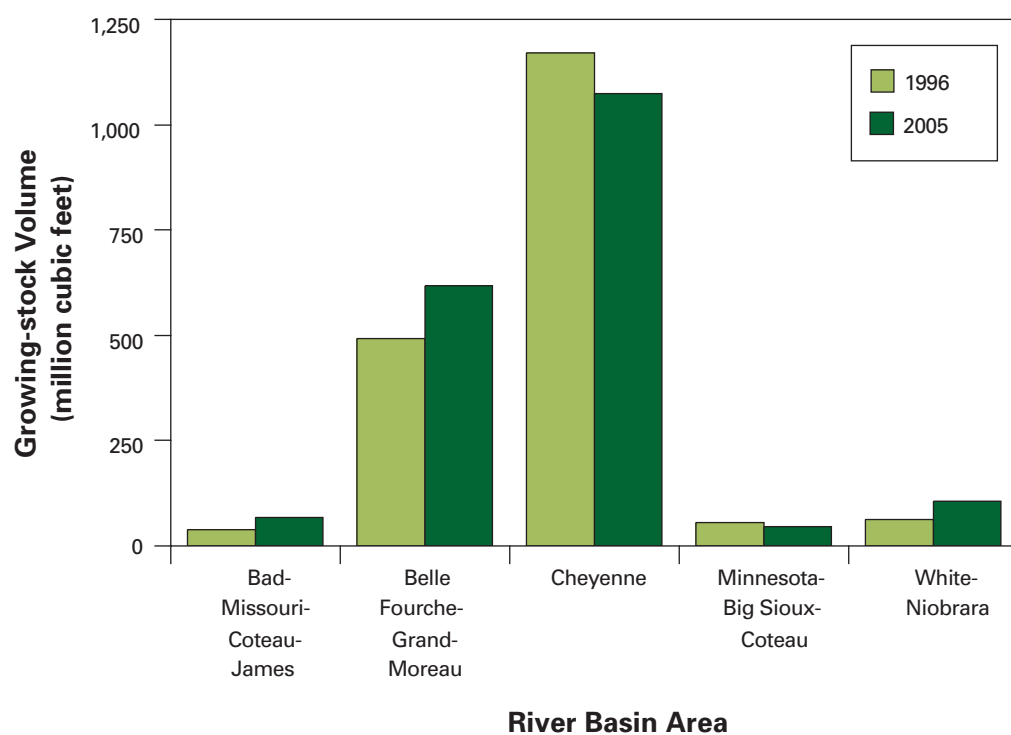
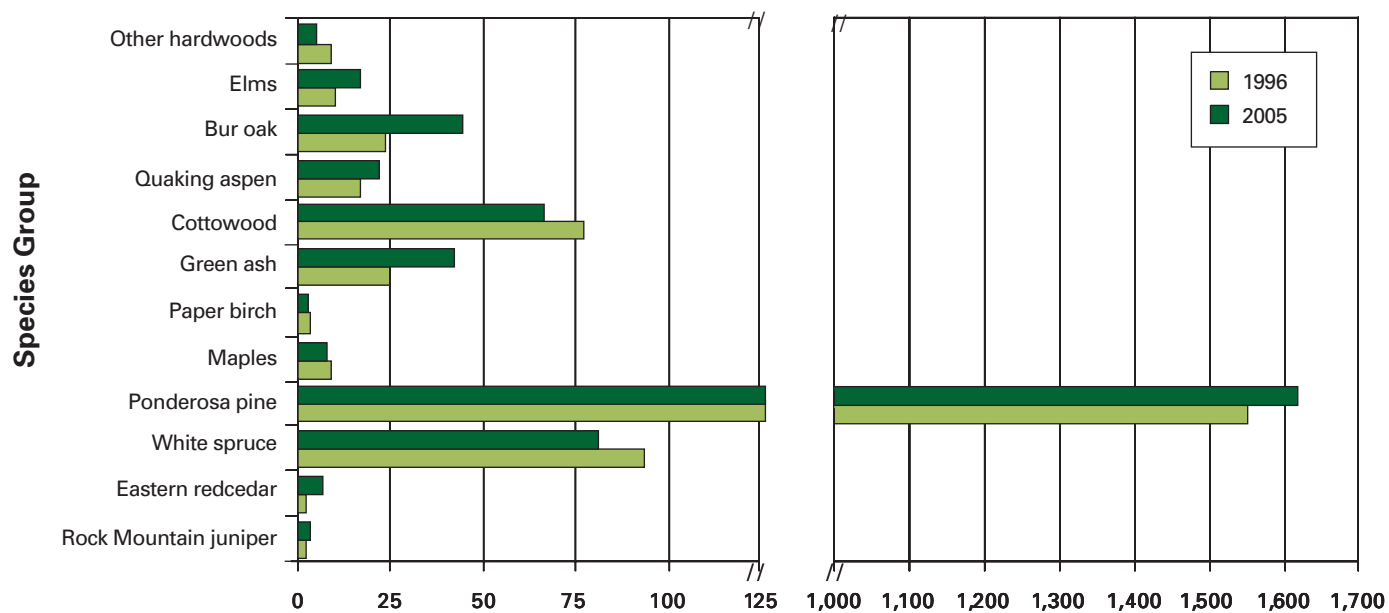


Figure 46.—Growing-stock volume on timberland by species in South Dakota, 1996 and 2005.



Sawtimber Volume

Background

Net sawtimber volume is an important indicator of the economic value of South Dakota's forests. These forest resources not only provide direct economic benefit through timber sales, but also support the secondary industries of sawtimber processing and final product manufacture (e.g., furniture).

What we found

While growing-stock volume increased by 5 percent between 1996 and 2005, the volume of sawtimber in 2005 remained at the 1996 level of 6.6 million board feet (Fig. 47). Hardwood sawtimber volume did increase by 7 percent between the 1996 inventory and the 2005 inventory, but a half-percent decrease in softwood sawtimber volume offset any gains.

The volume of sawtimber on timberland increased by 71 percent in the Bad-Missouri-Coteau-James RBA, by 63 percent in the White-Niobrara RBA, and by 12 percent in the Belle Fourche-Grand-Moreau RBA (Fig. 48). Sawtimber volume decreased by 11 percent in the Cheyenne RBA and by 22 percent in the Minnesota-Big Sioux-Coteau RBA.

Statewide, there was an average of 4,300 board feet of sawtimber per acre of timberland in 2005. The Belle Fourche-Grand-Moreau RBA had the greatest volume of sawtimber per acre at 6,100 board feet per acre (Fig. 49), followed by the Cheyenne RBA with 4,100 board feet per acre, the Minnesota-Big Sioux-Coteau RBA with 3,500 board feet per acre, the White-Niobrara RBA with 2,800 board feet per acre, and the Bad-Missouri-Coteau-James RBA with 1,900 board feet per acre.

What this means

Because the Cheyenne RBA contains more than half of both the timberland area and sawtimber volume, the decrease in sawtimber volume between 1996 and 2005 resulted in a 1-percent decrease in the state average volume of sawtimber per acre of timberland between 1996 and 2005. The sawtimber volume per acre of timberland in the Cheyenne RBA decreased from 4,300 board feet per acre in 1996 to 4,100 board feet per acre in 2005, a decrease of 5 percent. The other four RBAs had increases in the volume of sawtimber per acre of timberland.

Figure 47.—Sawtimber volume on timberland by hardwoods and softwoods, and inventory year in South Dakota.

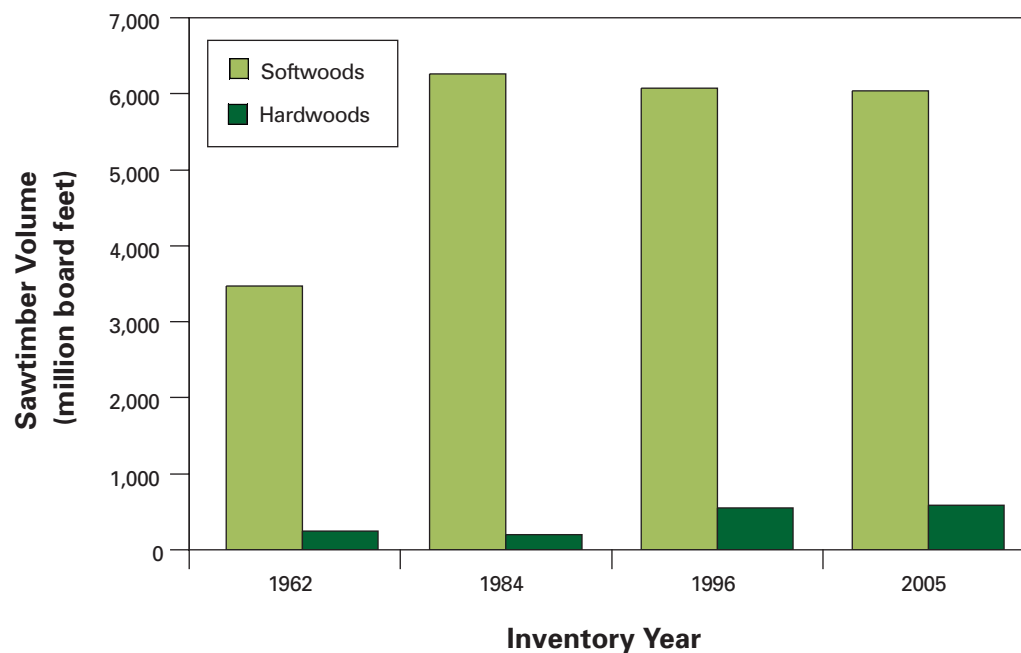


Figure 48.—Sawtimber volume on timberland by River Basin Area in South Dakota, 1996 and 2005.

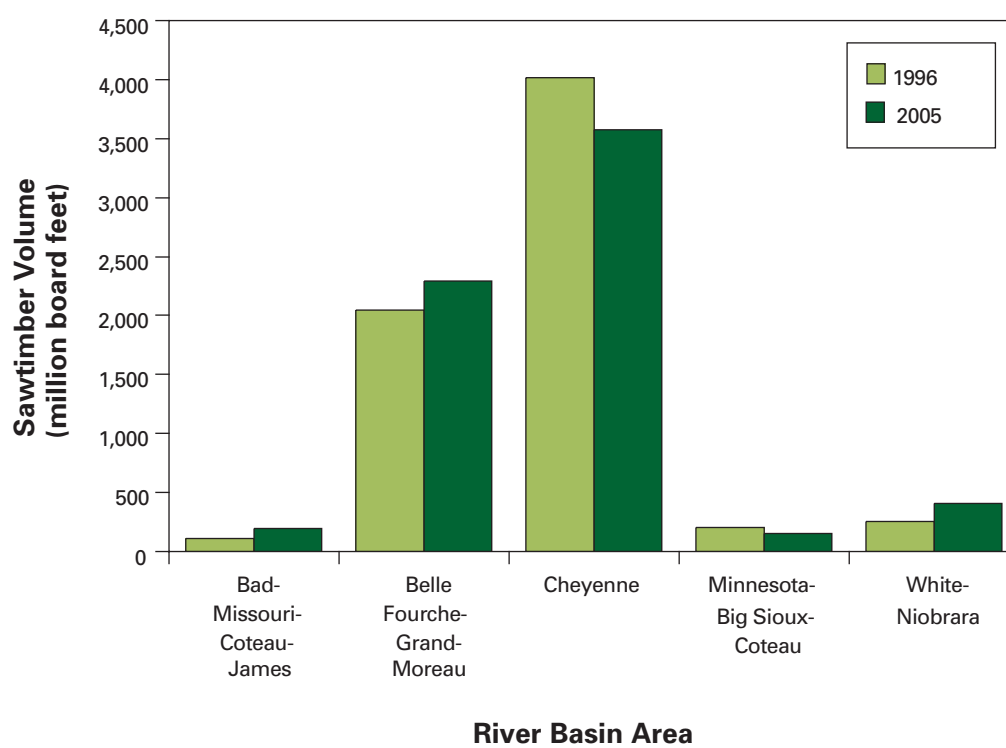
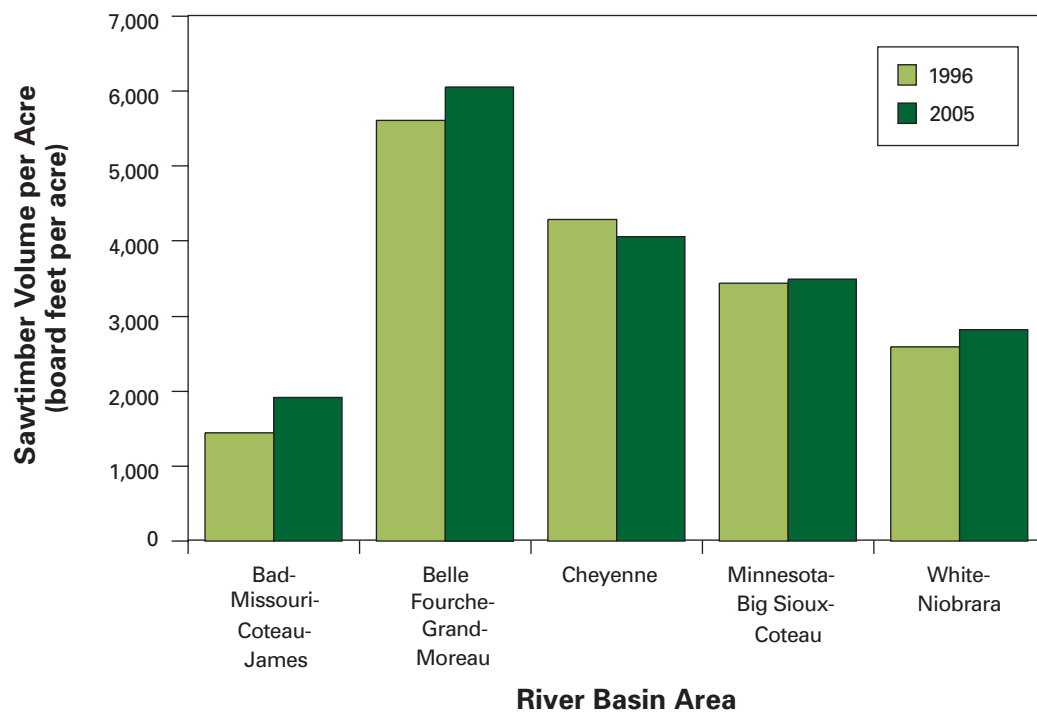


Figure 49.—Average sawtimber volume per acre on timberland by River Basin Area in South Dakota, 1996 and 2005.



Timber Product Output

Background

Through the process of converting harvested trees into products such as lumber, posts, particleboard, or cabin logs, South Dakota's forest resource provides income to both woodland owners and wood-processing mills. To better understand the effects of the primary wood use and manufacturing sector on the economy and that sector's impacts on forests, it is important to monitor timber products outputs.

What we found

Inventories of the primary wood-using industries of South Dakota are conducted periodically to estimate the amount of wood volume that is processed into products (see the section on the Timber Products Output Survey). The two most recent surveys were conducted for 1999 (Piva and Josten 2003) and 2004 (Piva et al. 2006). In 2004, there were 25 primary wood-processing mills in South Dakota, which processed 24.7 million cubic feet of industrial roundwood. Almost 75 percent of the wood these mills processed came from the forest lands of South Dakota. Almost all (99 percent) of what is imported is ponderosa pine from Montana, Nebraska, and Wyoming.

In 2004, 21.4 million cubic feet of industrial roundwood was harvested in South Dakota. More than 90 percent of this wood went to sawmills to produce lumber and pallet stock (Fig. 50). Other products that utilized industrial roundwood were pulpwood, posts, cabin logs, and excelsior or shavings. Ponderosa pine was the primary species harvested, making up 95 percent of the total harvest (Fig. 51).

Not all of the wood material cut from forest land is processed into primary products. In the process of harvesting the timber, 8.7 million cubic feet of wood material was left on the ground as harvest residue. At the mill, sawing and processing the industrial roundwood into products generated more than 381,000 green tons of mill residues. Only 3,000 green tons of this mill residue was not used for a secondary product such as fiber products, industrial fuel, domestic fuel, livestock bedding, and mulch.

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. The hardwood resource throughout most of South Dakota is currently being only lightly utilized. Because 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 logging residues for fiber products or biofuel facilities has potential for the Black Hills area of the State. The forest products industry in the rest of South Dakota is scattered, so utilization of logging residues for fiber products or biofuel facilities has limited, localized potential. Almost all of the mill residue is currently being used for other products such as fiber products and industrial fuel.

Figure 50.—Industrial roundwood production by product harvested in South Dakota, 1999 and 2004.

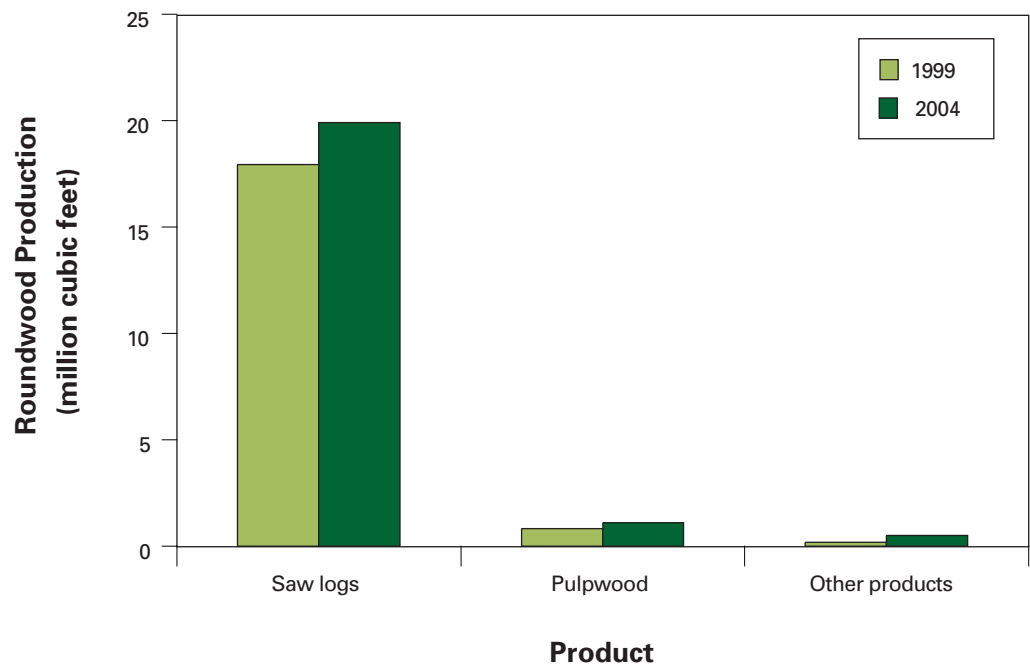
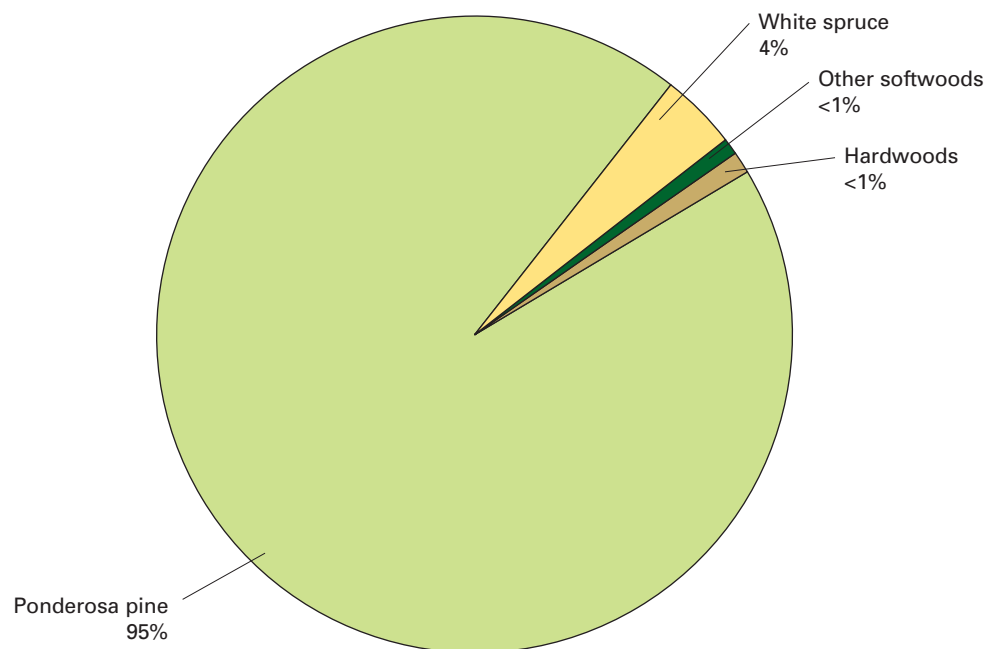


Figure 51.—Industrial roundwood production by species harvested in South Dakota, 2004.



Data Sources and Techniques



Forest Inventory

The NRS-FIA program began fieldwork for the fifth inventory of South Dakota forest resources in 2001. This launched the new annual inventory system in which one-fifth of the field plots (considered one panel) are measured each year. In 2005, NRS-FIA completed measurement of the fifth and final panel of inventory plots in South Dakota. Now that all panels have been measured, each will be remeasured every 5 years. Previous inventories of South Dakota's forest resources were completed in 1935, 1962 (all lands west of the 103rd meridian were inventoried in 1960 and east of the 103rd meridian were inventoried in 1964), 1984 (all lands east of the 103rd meridian were inventoried in 1979 and west of the 103rd meridian were inventoried in 1983), and 1996 (the area outside the Black Hills National Forest was inventoried in 1996 and the Black Hills National Forest was inventoried in 1999) (Chase 1967, Choate and Spencer 1969, Collins and Green 1988, Collins and Green 1989, DeBlander 2002, Leatherberry et al. 2000, Raile 1984, Ware 1936). All lands west of the 103rd meridian were inventoried in 1971 to 1974 (Green 1978), but land to the east of the 103rd meridian was not inventoried. Therefore, no trend information is given for this time period.

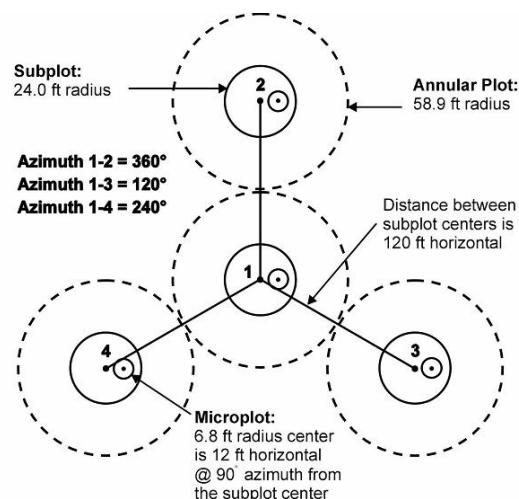
Data from new inventories are often compared with those from earlier inventories to determine trends in forest resources. However, for the comparisons to be valid, the procedures used in the two inventories must be similar. As a result of our ongoing efforts to improve the efficiency and reliability of the inventory, several changes in procedures and definitions have been made since the last South Dakota inventory in 1996 (Leatherberry et al. 2000). Although these changes will have little impact on statewide estimates of forest area, timber volume, and tree biomass, they may significantly impact plot classification variables such as forest type and stand-size class (especially county-level estimates). For estimating growth, removals, and mortality, only the 1999 inventory of the Black Hills National Forest (DeBlander 2002) was processed using estimation/summary routines for the 2001-2005 inventory. Although these changes allow limited comparison of inventory estimates among separate inventories in this report, it is inappropriate to directly compare all portions of the 2001-2005 data with those published for earlier inventories.

The 2001-2005 South Dakota forest inventory was done in three phases. During the first phase, we used a computer-assisted classification of satellite imagery to form two initial strata, forest and nonforest. Pixels within 60 m (2 pixel widths) of a forest/nonforest edge formed two additional strata—forest/nonforest and nonforest/forest. Forest pixels within 60 m on the forest side of a forest/nonforest boundary were classified into a forest edge stratum. Pixels within 60 m of the boundary on the nonforest side were classified into a nonforest edge stratum. The estimated population total for a variable is the sum across all strata of the product of each stratum's estimated area and the variable's estimated mean per unit area for the stratum.

The second phase of the forest inventory consisted of the actual field measurements. Current FIA precision standards for annual inventories require a sampling intensity of one plot for approximately every 6,000 acres. The entire area of the United States has been divided into nonoverlapping hexagons, each containing 5,937 acres (McRoberts 1999). The total Federal base sample of plots has been systematically divided into five interpenetrating, nonoverlapping subsamples or panels. Each year the plots in a single panel are measured, and panels are selected on a 5-year, rotating basis (McRoberts 1999). For estimation purposes, the measurement of each panel of plots may be considered an independent systematic sample of all land in a state. Field crews measured vegetation on Black Hills National Forest plots that were forested at the time of the last inventory and on plots statewide that were currently classified as forest by trained photointerpreters using aerial photos or digital orthoquads.

NRS-FIA has two categories of field plot measurements—Phase 2 (P2) field plots (standard FIA plots) and Phase 3 (P3) plots (forest health plots) to optimize our ability to collect data when available for measurement. A suite of tree and site attributes is measured on P2 plots, while a full suite of forest health variables is measured on P3 plots. Both plot types are uniformly distributed both geographically and temporally. The 2001-2005 annual inventory results represent field measurements on 325 P2 forested plots and 26 P3 plots.

Figure 52.—NRS-FIA field plot design in South Dakota, 2001-2005.



The overall P2 plot layout consists of four subplots (Fig. 52). The centers of subplots 2, 3, and 4 are located 120 feet from the center of subplot 1. The azimuths to subplots 2, 3, and 4 are 360, 120, and 240 degrees, respectively. Trees with a d.b.h. of 5 inches and larger are measured on a 24-foot-radius (1/24-acre) circular subplot. All trees less than 5 inches in d.b.h. are measured on a 6.8-foot-radius (1/300-acre) circular microplot located 12 feet east of the center of each of the four subplots. Forest conditions that occur

on any of the four subplots are recorded. Factors that differentiate forest conditions are changes in forest type, stand-size class, land use, ownership, and density. For details on the sample protocols for P2 variables and all P3 indicators, please refer to <http://fia.fs.fed.us/library/fact-sheets/>.

National Woodland Landowner Survey

The National Woodland Landowner Survey is conducted annually by the Forest Service to increase our understanding of private woodland owners – the critical link between society and forests. Each year, questionnaires are mailed to individuals and private groups who own the woodlands where NRS-FIA has established inventory plots (Butler et al. 2005). Twenty percent of these ownerships (about 50,000 nationwide) are contacted each year, and more detailed questionnaires are mailed in years that end in 2 or 7 to coincide with national census, inventory, and assessment programs. The target accuracies of the data are plus or minus 10 percent at the state level. More information about ownership of South Dakota's forest land can be obtained from the National Woodland Owner Survey Web site (www.fia.fs.fed.us/nwos) or Butler (2008).

Insects and Diseases

Information about the insects and diseases affecting South Dakota's forests was gathered from the 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. To view and download aerial survey information for South Dakota, please visit <http://www.fs.fed.us/r2/resources/fhm/aerialsurvey/download/>. Additional information on the Rocky Mountain Region's Forest Health Management program is available at <http://www.fs.fed.us/r2/fhm/>. For more information on the health of South Dakota's forests, contact the SDDA Division of Resource Conservation and Forestry.

Timber Products Output Survey

The timber products output survey was a cooperative effort between the SDRCF and the Northern Research Station (NRS). The SDRCF canvassed all primary wood-using mills within the State using mail questionnaires supplied by the NRS 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 a nearly 100-percent response was achieved. Completed questionnaires were forwarded to NRS 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 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 State roundwood to provide a complete assessment of South Dakota's timber product output.

National Land Cover Data Imagery

The National Land Cover Dataset (NLCD) is derived from Landsat Thematic Mapper data. It is a land cover classification of 21 classes and has a spatial resolution, or pixel size, of 30 m. This classification scheme is applied across the United States by the U.S. Geological Survey (USGS) and the U.S. Environmental Protection Agency (EPA). The NLCD was developed from data acquired by the Multi-Resolution Land Characterization (MRLC) Consortium, a partnership of Federal agencies that produce or use land cover data. Partners include the USGS, EPA, Forest Service, and the National Oceanic and Atmospheric Administration (NOAA).

Mapping Procedures

Maps in this report were created using three different methods. The first 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 5. The second 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 final procedure used colored dots to represent plot attributes at approximate plot locations. Figure 14 is an example of this type of map.

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The first completed annual inventory of South Dakota's forests reports almost 1.7 million acres of forest land. Softwood forests make up 74 percent of the total forest land area; the ponderosa pine forest type by itself accounts for 69 percent of the total.

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

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