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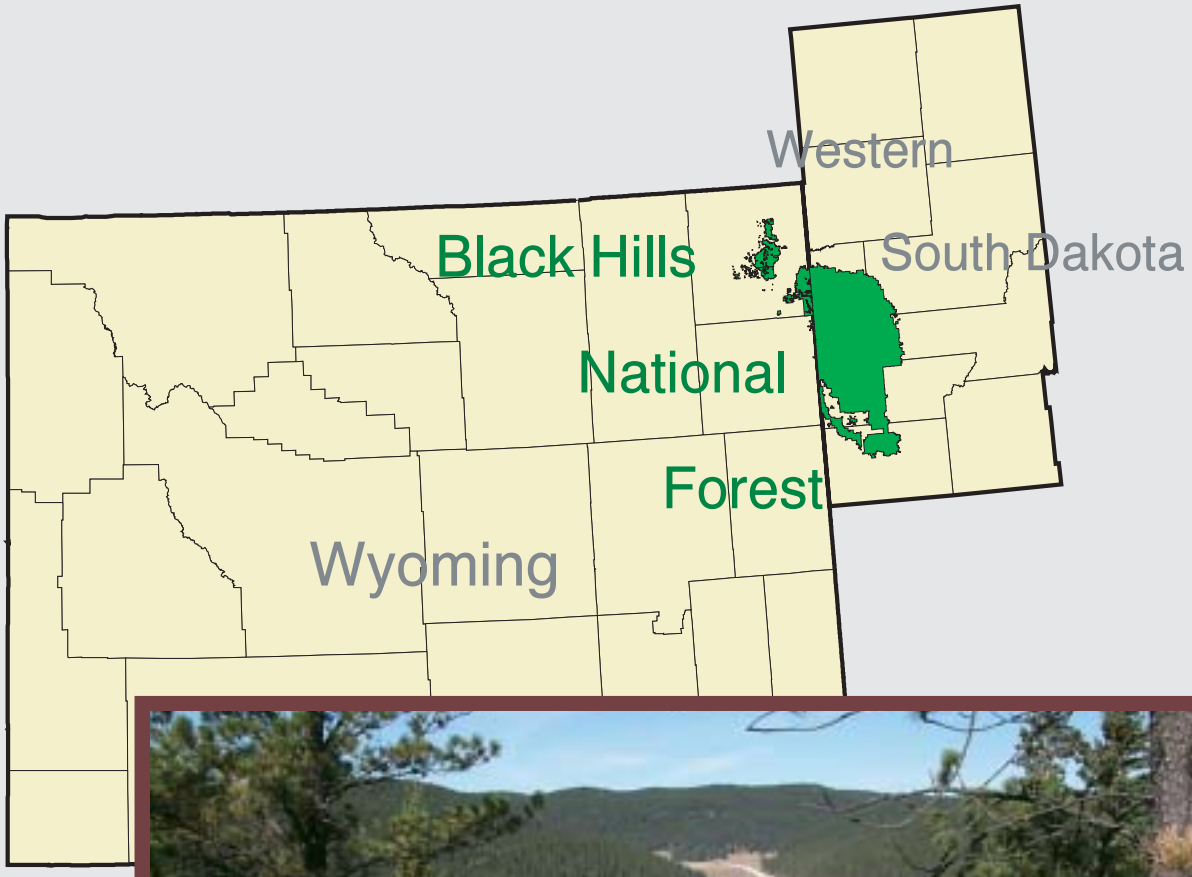
Forest Service

Rocky Mountain Research Station

August 2002

Forest Resources of the Black Hills National Forest

Larry T. DeBlander



About the author

Larry T. DeBlander is a Forester with the Interior West Forest Inventory and Analysis Program, Rocky Mountain Research Station in Ogden, Utah.

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Cover photo by Blaine Cook, Forest Silviculturist,
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Forest Resources of the Black Hills National Forest

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The Interior West Forest Inventory and Analysis (IWFIA) Program of the USDA Forest Service, Rocky Mountain Research Station, as part of our National Forest System cooperative inventories, conducted a forest resource inventory on the Black Hills National Forest using a nationally standardized mapped-plot design (for more details see section "How was the inventory conducted?" page 11). This report presents the highlights of this 1999 periodic inventory using commonly requested variables and summaries. The data could be summarized in other ways for different purposes (see "For further information" on the inside back cover). The information presented in this report is based solely on the IWFIA inventory sample (USDA 1999). Supplementary documentation and inventory terminology can be located in USDA (2002b). Additional data collected by the Black Hills National Forest and used separately or in combination with IWFIA data may produce varying results. Changes since the inventory, such as the impact of more than 130,000 acres burned from large fires on the Forest (USDA 2002a), have not been incorporated into this report. Annual inventories will soon replace periodic inventories to help monitor these changes at shorter intervals. References to the "Black Hills" in this report pertain to National Forest System lands and not the general geographic area.

What forest resources are found on the Black Hills National Forest?

The Black Hills National Forest administers 1,246,985 acres (USDA 2000; 2002b) of which 92 percent is forest land and 8 percent is nonforest or water (fig. 1). One percent of the total area on the Black Hills National Forest is in a reserved designation in the Black Elk Wilderness. Reserved lands are those areas that have been withdrawn from management for production of wood products, such as wilderness areas or National Parks. This report focuses on forest resources of all the forest land administered by the Black Hills National Forest, including reserved lands.

Forest type—Forest resources are often described using a forest type classification. Forest type refers to the predominant tree species in a stand, based on plurality of tree stocking. Stocking is an expression of the extent to which growing space is effectively utilized by live trees.

Forest types are dynamic and can change slowly through forest succession, or rapidly due to disturbances such as timber harvest, fire, or insect and disease epidemics. On the Black Hills, ponderosa pine at 85 percent is the most common forest type by percentage of total forest land area. Ponderosa pine is followed in abundance by white spruce forest type at 5 percent, aspen, bur oak, and paper birch at 3 percent each, and juniper woodland at less than 1 percent (fig. 2).

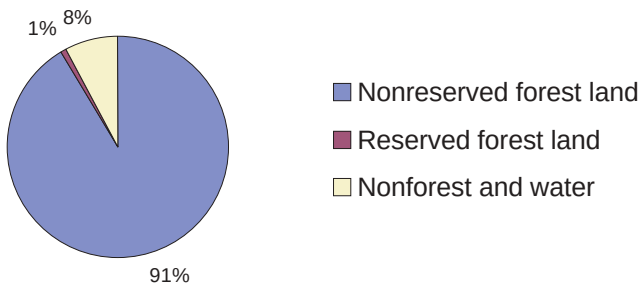

Figure 1—Percent area by land class and reserved status, Black Hills National Forest, 1999.

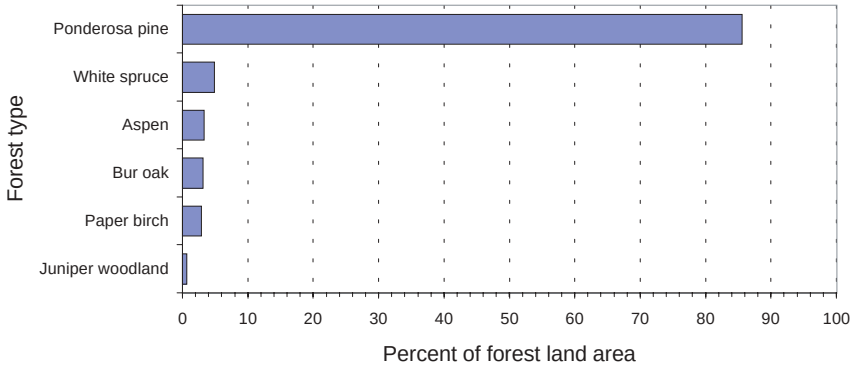

Figure 2—Percent of forest land area by forest type, Black Hills National Forest, 1999.

Size—The size distribution of trees in a stand is an indicator of structural diversity. Figure 3 displays the tree size distribution by diameter class on the Black Hills. Overall, this shows a typical diameter distribution with a higher number of small trees than large trees.

Stand-size class is a classification of forest land based on the predominant diameter-size of live trees that contribute to the majority of stocking**.** The large diameter class includes softwoods 9.0 inches diameter and greater, and hardwoods 11.0 inches diameter and greater; the medium diameter class includes softwoods 5.0 to 8.9 inches diameter, and hardwoods 5.0 to 10.9 inches diameter; and the saplings/seedlings class includes all trees under 5.0 inches diameter. In terms of stocking, fewer large-diameter trees compared to small-diameter trees are required to fully utilize a site. Figure 4 displays a breakdown of forest land on the Black Hills by area and stand-size class. Sixty-six percent of the stands have a majority of stocking from large trees and only 2 percent are nonstocked, such as stands that have been recently harvested or burned.

Figure 5 shows the area of forest land by forest type and stand-size class on the Black Hills. Sixty-one percent of the total forest land area is in the ponderosa pine, large tree category.

Number and basal area of live trees—Another way to assess forest diversity is by examining the composition of forest land by tree diameter and species. Figure 6 shows total number of live trees by species in three diameter-size classes. Sixty percent of all live trees on the Black Hills are from 1.0 to 4.9 inches diameter, 24 percent are from 5.0 to 8.9 inches diameter, and 16 percent are 9.0 inches diameter and greater. Ponderosa pine makes up 76 percent of the total number of trees; aspen, 8 percent; paper birch, 5 percent; bur oak and white spruce, 4 percent each; Rocky Mountain juniper, 3 percent; and a trace of green ash. Species that are scarce may not be encountered with the extensive sampling strategy used for this inventory.

Basal area is the cross-sectional area of a tree stem/bole (includes bark) at the point of diameter measurement, usually expressed in square feet. Figure 7 displays the total number of live trees and basal area for all species combined by 2-inch diameter classes.

Figure 8 shows the number of live trees by species and elevation class. Elevation is associated with variations in local climate. For example, precipitation generally increases with rising elevation, while temperature decreases. These factors have a profound impact on a tree species' ability to compete with other species at various elevations. On the Black Hills, the predominant species at all elevations is

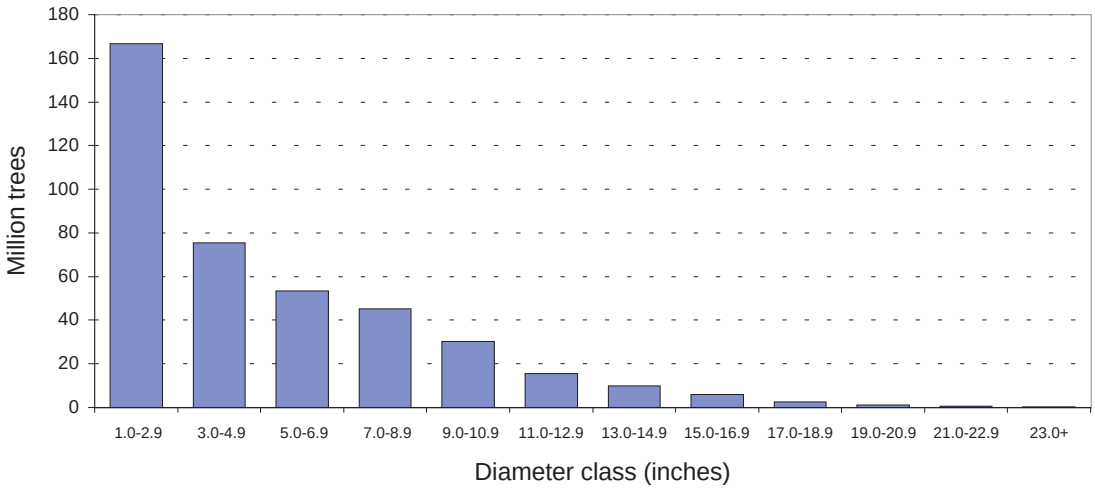

Figure 3—Number of live trees on forest land by diameter class, Black Hills National Forest, 1999.

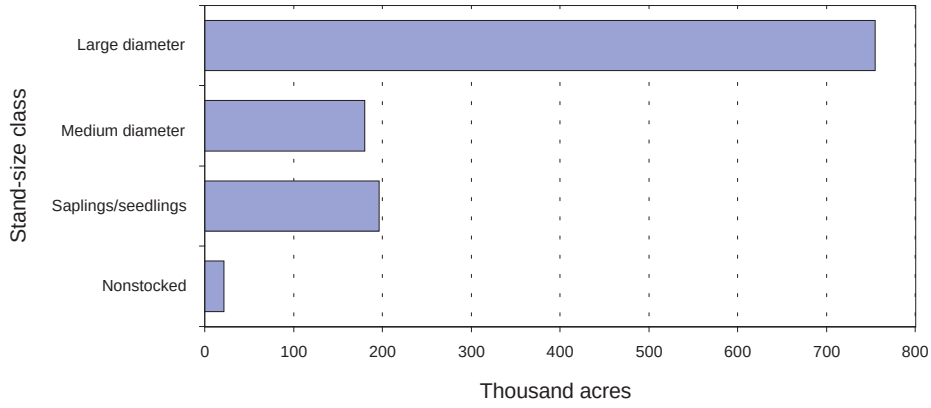

Figure 4—Forest land area by stand-size class, Black Hills National Forest, 1999. Large diameter includes softwoods 9.0"+ and hardwoods 11.0"+; medium diameter includes softwoods 5.0" to 8.9" and hardwoods 5.0" to 10.9"; saplings/seedlings include trees <5.0".

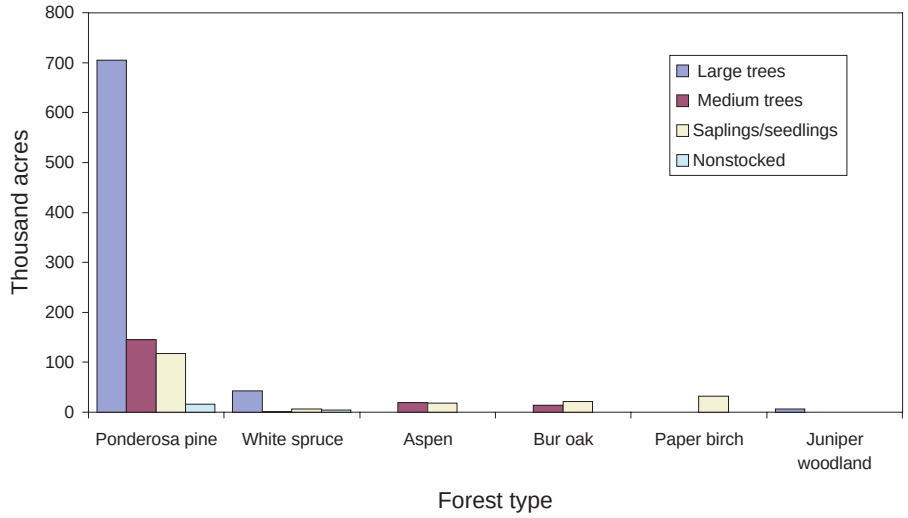

Figure 5—Area of forest land by forest type and stand-size class, Black Hills National Forest, 1999.

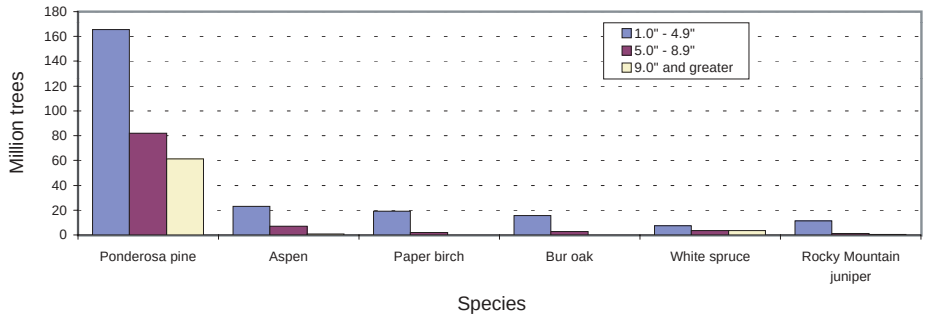

Figure 6—Number of live trees 1.0 inch diameter and greater on forest land by species and diameter-size class, Black Hills National Forest, 1999.

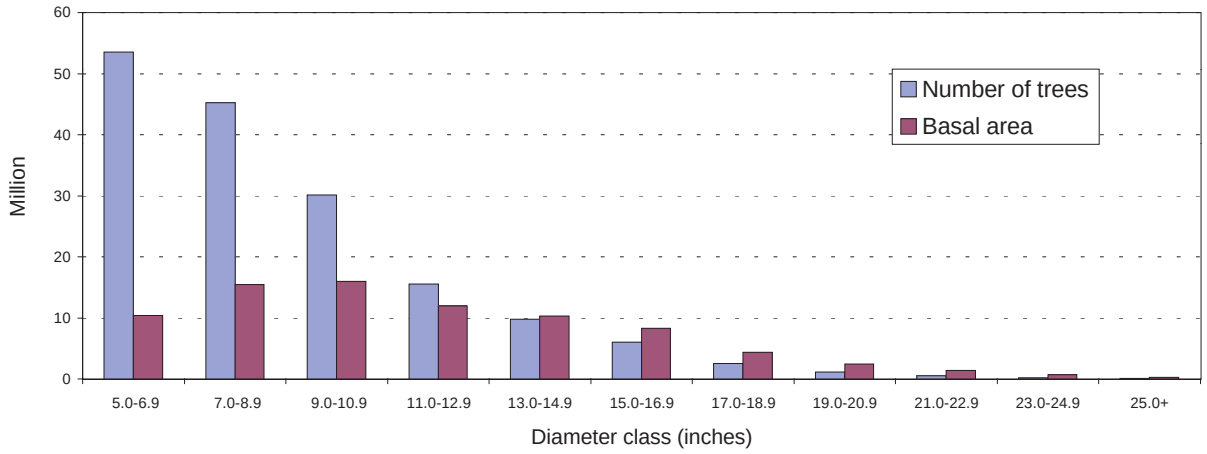

Figure 7—Total number of live trees and basal area (sq. ft.) on forest land by diameter class, Black Hills National Forest, 1999.

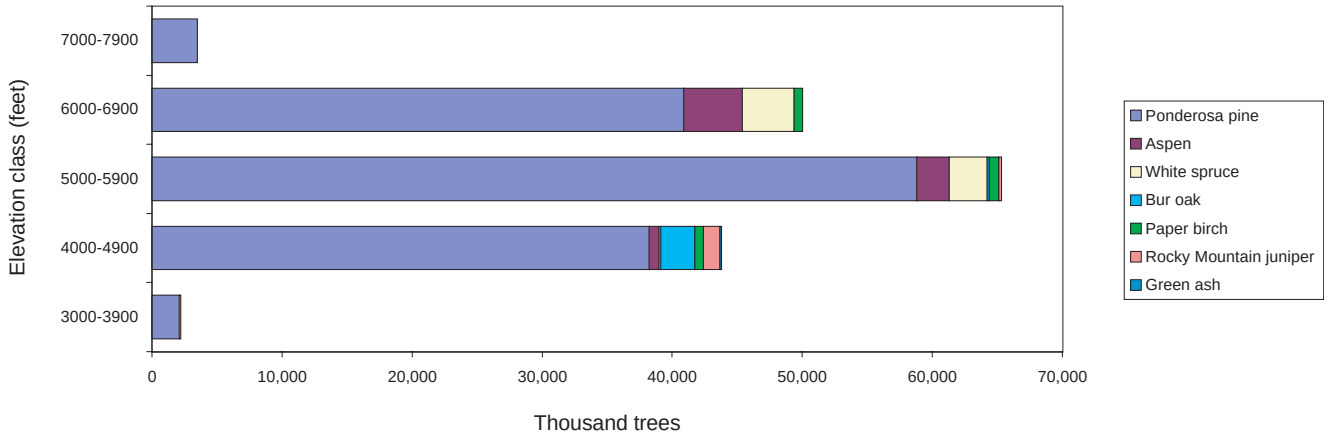

Figure 8—Number of live trees 5.0 inches diameter and greater on forest land by species and elevation class, Black Hills National Forest, 1999. Sample site elevation determined to nearest 100 feet.

ponderosa pine. After ponderosa pine, bur oak, Rocky Mountain juniper, and paper birch are the predominant species at lower elevations, and aspen and white spruce at higher elevations.

Number and weight of dead trees—Standing and down dead trees are an important component of forest ecosystems, with many uses such as providing habitat for wildlife and functioning as nutrient sinks. Approximately 10.9 million standing dead trees (snags) and 18.5 million down dead trees 5.0 inches diameter and greater are on forest land on the Black Hills. If trees 1.0 inches diameter and greater are included there are 40.5 and 60.1 million, respectively.

Many animals are dependent upon snags, but the species, size, and density of snags required for quality habitat vary according to the species of wildlife. Large diameter snags are generally scarce relative to smaller snags. Considering snags 11.0 inches diameter or larger, an estimated 2.7 per acre occur on Black Hills forest land. Of the very large snags (19.0 inches diameter or larger) there is an estimated 0.3 per acre. Ponderosa pine and white spruce were the only species sampled with snags in the 19-inch and larger category.

The amount of dead material can contribute significantly to forest fuel loads. About 2 million tons of down dead trees and 1.9 million tons of standing dead trees are on Black Hills forest land. This estimate includes the merchantable bole and bark of trees 5.0 inches diameter and greater. Figure 9 shows the weight per acre of down dead trees by stand-size class for the six predominant types and all forest types combined. For all forest types combined, the saplings/seedlings stand-size class has the highest weight at 2.0 tons per acre, followed by the large tree class at 1.7 tons per acre. For all stand-size classes combined, the white spruce type has the highest weight at 5.6 tons per acre, followed by paper birch at 3.7 tons per acre. Some class breakdowns such as the white spruce saplings/seedlings class may not be representative due to small sample size.

Stand age—Figure 10 displays the percent of forest land area by forest type and stand-age class on the Black Hills. This figure shows the 81- to 90-year class as the most common on the Forest. Stand age can indicate the duration since the last extensive disturbance of the forest overstory.

Stand age for this report is estimated from core samples of live trees. Estimation of stand age is limited to trees with diameters that fall within a stand's designated stand-size class. Many other factors affect the number of sample trees available for determining stand age. In general, stand age for dense stands that contain more core sample trees is probably more representative than stand age for sparse stands that contain less.

Wood volume, biomass, and basal area of live trees—Estimates of cubic-foot volume and basal area include all live trees 5.0 inches diameter and greater. Biomass estimates include boles, bark, and branches of all live trees 1.0 inches diameter and greater. The net volume of wood on the Black Hills is estimated to be in excess of 1.6 billion cubic feet. Total biomass of wood on the Black Hills is estimated at over 32 million tons. Table 1 is a breakdown of volume and biomass by species.

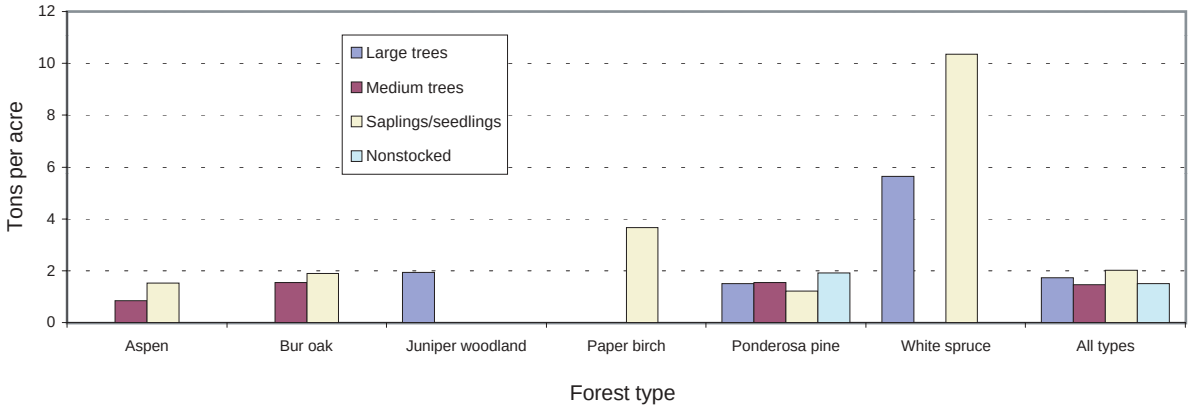

Figure 9—Weight of down dead trees 5.0 inches diameter and greater on forest land by forest type and stand-size class, Black Hills National Forest, 1999.

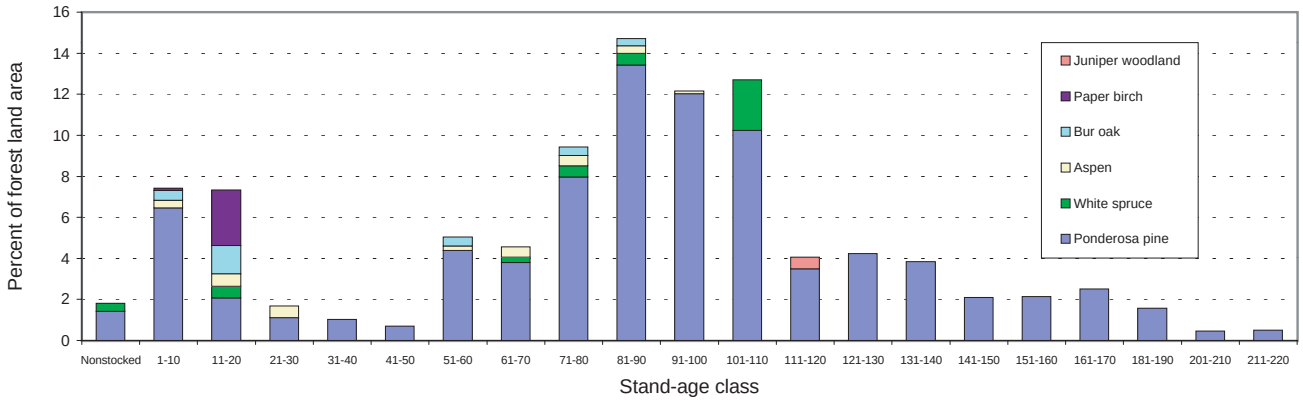

Figure 10—Percent of forest land area by forest type and stand-age class, Black Hills National Forest, 1999.

Table 1—Net volume and biomass on forest land by species, Black Hills National Forest, 1999.

Species	Volume (Million cubic-feet)	Biomass (Million tons)
Ponderosa pine	1,535.3	30.1
White spruce	92.7	1.5
Aspen	19.8	0.5
Paper birch	4.2	0.2
Rocky Mountain juniper	3.3	0.1
Bur oak	3.2	0.1
Green ash	0.3	*
Total	1,658.8	32.5

* – Less than 100,000

Figure 11 displays the percent net cubic-foot volume of live trees by diameter class. Over 80 percent of this volume is in the 9.0- to 10.9-inch and greater diameter class. As expected, a breakdown by species shows approximately 84 percent of white spruce and 81 percent of ponderosa pine volume are in trees 9.0 inches diameter and greater. In contrast, about 31 percent of aspen volume is in trees 9.0 inches diameter and greater.

Another way to look at wood volume is by forest type, for which estimates per acre can be computed along with basal area (table 2). These numbers include the many different species that can occur together within each forest type. The highest volume per acre on the Black Hills is in the white spruce forest type. The highest basal area per acre is in the ponderosa pine forest type. Volume and basal area per acre for juniper woodland may not be representative due to the small sample size. One characteristic of the mapped-plot design is that a plot may sample more than one condition (see last two columns of table 2). A forest condition is generally defined as an area of relatively homogeneous vegetative cover that meets the criteria for forest land. Forest type is one of several attributes that define and separate conditions identified on the plot.

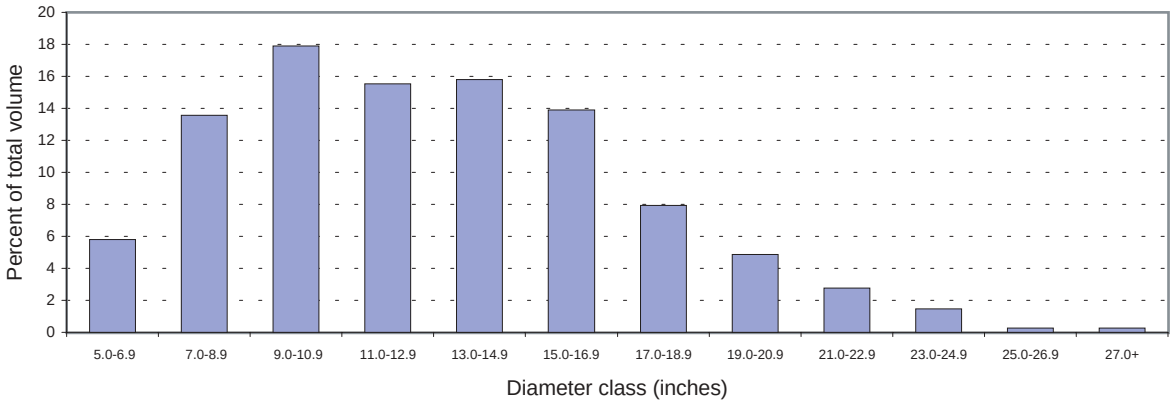

Figure 11—Percent net cubic foot volume of live trees on forest land by diameter class, Black Hills National Forest, 1999.

Table 2—Net volume per acre, basal area per acre, number of conditions, and condition proportions on forest land by forest type, Black Hills National Forest, 1999.

Forest type	Net cubic-foot volume per acre	Basal area sq. ft. per acre	Number of conditions[a]	Condition proportions[b]
White spruce	1,586	65	12	8.6
Ponderosa pine	1,542	75	183	159.5
Juniper woodland	591	60	1	1.0
Aspen	576	47	11	6.7
Paper birch	564	28	6	5.3
Bur oak	288	25	9	7.5
Total			222	188.6

[a]Number of conditions by forest type that were sampled. These numbers are often greater than the total number of plots by forest type because a plot may sample more than one forest condition.

[b]Sum of the condition proportions of plots by forest type that were sampled. These numbers are often less than the total number of plots by forest type because of nonforest condition proportions (from plots containing both forest and nonforest conditions) that are not included here.

The net volume of sawtimber trees (sawtimber volume) on the Black Hills is estimated to be over 6.1 billion board feet (International ¼-inch rule). This includes all growing-stock trees 9.0 inches diameter and greater for softwoods, and 11.0 inches diameter and greater for hardwoods. Figure 12 illustrates the sawtimber volume on forest land by diameter class on the Black Hills. The 13.0- to 14.9-inch diameter class has the most volume at 21 percent, followed by the 15.0- to 16.9-inch class at 20 percent. Ninety-four percent of the total sawtimber volume on the Black Hills is from ponderosa pine.

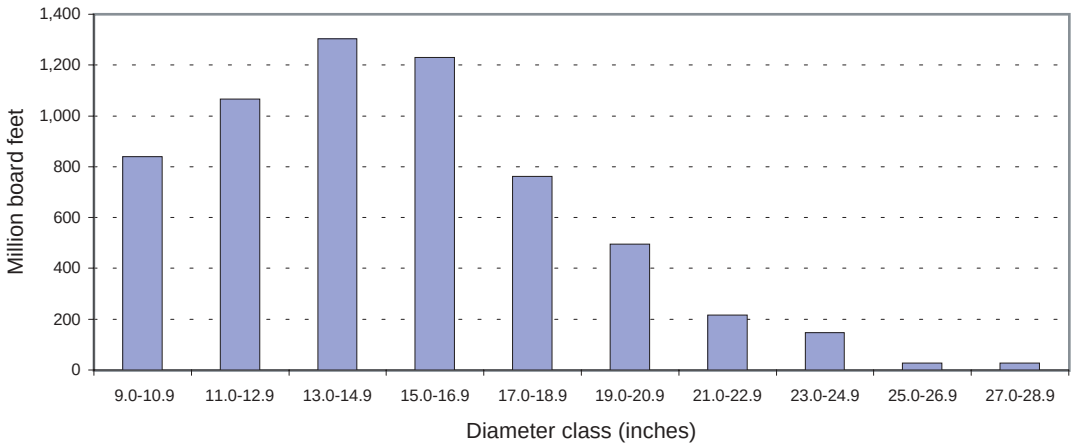

Figure 12—Sawtimber volume (International $^1/_4$-inch rule) on forest land by diameter class, Black Hills National Forest, 1999.

How does the forest change?

Stocking category—Many factors influence the rate at which trees grow and thrive, or die. As tree size and density increase, competition for available resources also increases. As mentioned earlier, stocking is an expression of the extent to which growing space on a site is effectively utilized by live trees. Information about stocking can apply to many issues, such as timber production and management, wildlife habitat suitability, and risk of attack by insects or disease. For this analysis, stocking of all live trees is presented in three classes. High stocking sites are those that are 60 or more percent stocked with live trees. Medium stocking sites are those 35 to 60 percent stocked with live trees. Low stocking sites are those that are less than 35 percent stocked with live trees.

The percent area by stocking category and forest type is shown in figure 13. High stocking indicates conditions where tree growth begins to slow and tree vigor starts to decrease, which can make trees more susceptible to attack by insects or disease. By this definition, about 27 percent of all forest land on the Black Hills is estimated to be in the high stocking category. This includes about 76 percent of the paper birch and 50 percent of the aspen forest types on the Black Hills. The juniper woodland type contains only one sample plot.

Growth—Another measure of forest vigor is net annual growth. Net annual growth is the difference between gross annual growth and losses due to mortality. Gross annual growth of live trees (5.0 inches diameter and greater) of all

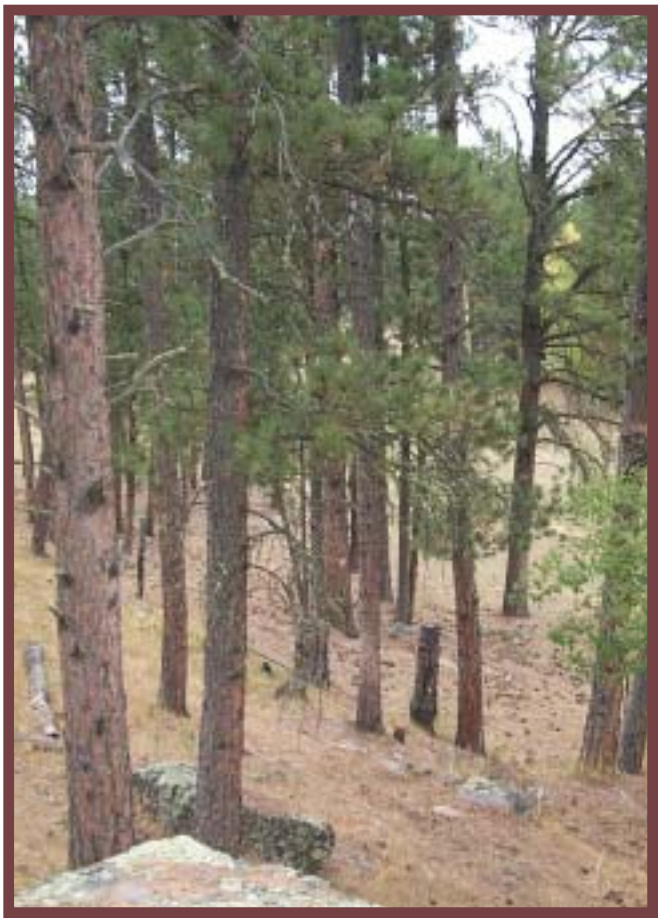

Photo by Blaine Cook

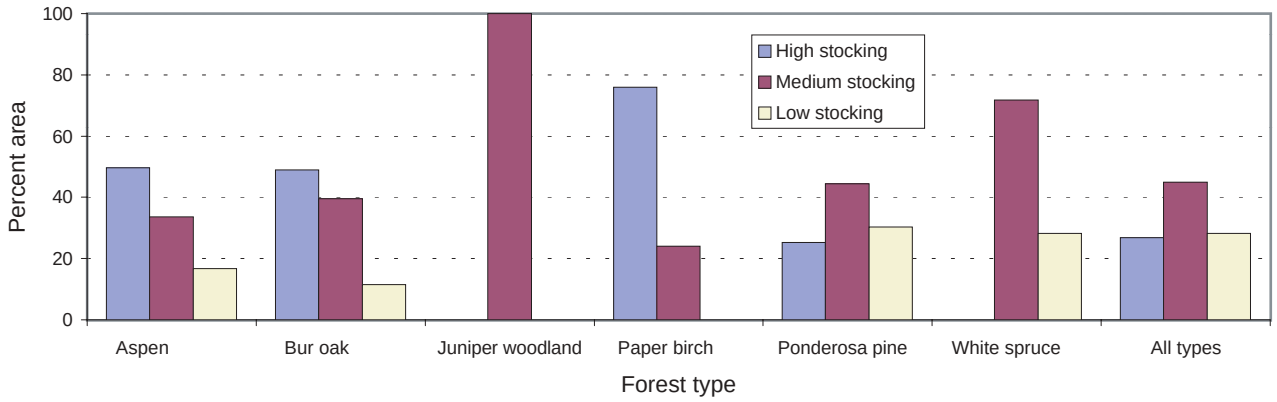

Figure 13—Percent area of live tree stocking category on forest land by forest type, Black Hills National Forest, 1999.

forest land on the Black Hills is estimated to be 43.1 million cubic feet, and net annual growth is 37.8 million cubic feet. Gross annual growth is compared to mortality for five high volume species in figure 14. Mortality of all forest land on the Black Hills is about 12 percent of gross annual growth, with the largest mortality-to-growth ratio for the five high volume species occurring in aspen. No mortality trees were sampled for Rocky Mountain juniper or green ash.

Mortality—Field crews assess which trees have died in the past 5 years; these trees are used to estimate an average annual mortality. Based on this estimate, in 1998, 5.2 million cubic feet of wood from live trees (5.0 inches diameter and greater) died on the Black Hills. About 69 percent of the mortality was caused by weather, 10 percent by insects, and 9 percent each by disease or fire. Eighty-one percent of the mortality occurred in ponderosa pine, 13 percent in white spruce, and 5 percent in aspen.

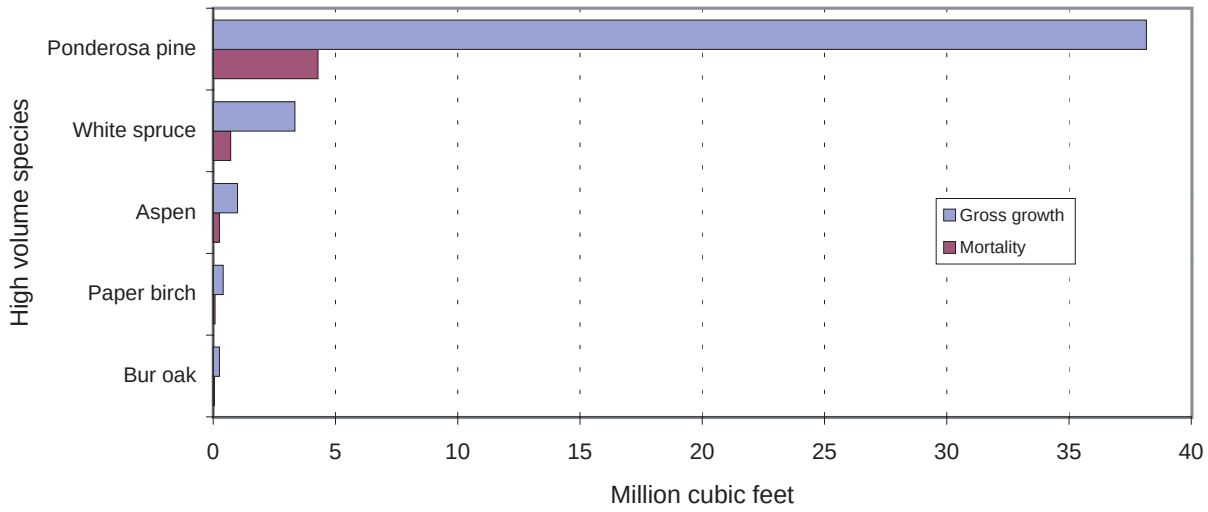

Figure 14—Gross annual growth of all live trees 5.0 inches diameter and greater compared to mortality for five high volume species on all forest land, Black Hills National Forest, 1999.

What other information is available about the forest land on the Black Hills National Forest?

Accessibility—All forested plots visited by field crews were assigned a "distance to road" category. Based on this information, it is estimated that 64 percent of the forested area on the Black Hills is less than a half mile from an improved road; 21 percent is between a half and 1 mile; 14 percent is between 1 and 3 miles; and 1 percent is between 3 and 5 miles. No plots were sampled greater than 5 miles from an improved road.

Burn and cutting history—Each forested plot was assessed separately for evidence of fire and cutting. Based on this 57 percent of the forested area on the Black Hills had some evidence of past fire that impacted the stand as a whole. Eighty-three percent of the forested area had some evidence of past timber or wood harvesting.

Type of disturbance—Field crews also evaluate each forested plot for the predominant human-caused influence or natural phenomenon that impact the stand. From this it was estimated that 5 percent of the forested area on the Black Hills had no visible signs of disturbance; 64 percent had evidence of fire and/or cutting; 6 percent each had evidence of wind or weather; 5 percent had evidence of road building; 2 percent each had evidence of insects or disease; about 1 percent total had evidence of animal damage or chaining; and 9 percent had evidence of other disturbance.

Understory vegetation—Understory vegetation provides forage and cover for wildlife, contributes to forest fuel load, and can be an indication of the successional stage of the forest community. On each plot field crews visually estimated crown canopy coverage for four plant groups—tree seedlings/saplings, shrubs, forbs, and graminoids (see USDA 1999 for details). Figure 15 shows the average percent cover of plant groups on forest land by forest type.

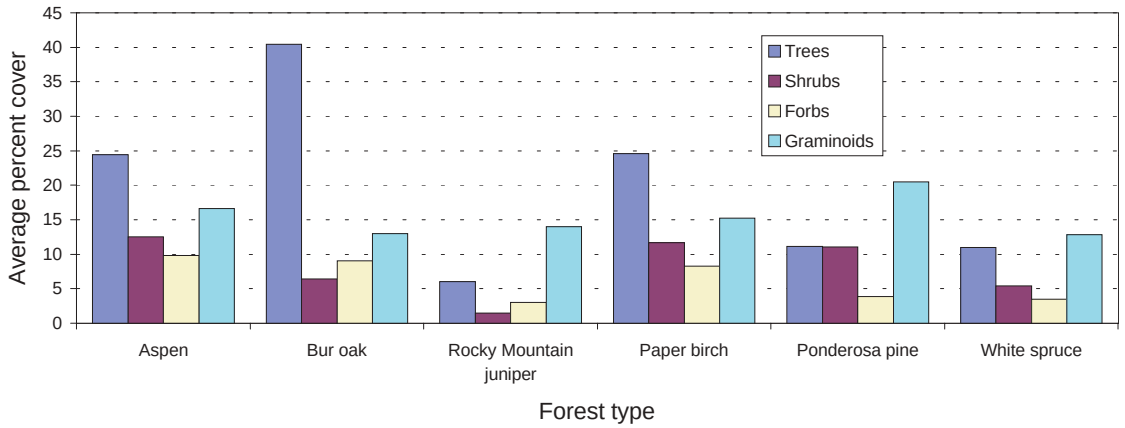

Figure 15—Average percent cover of trees (saplings/seedlings), shrubs, forbs, and graminoids on forest land by forest type, Black Hills National Forest, 1999.

How was the inventory conducted?

Forest Inventory and Analysis (FIA) provides a statistical-based sample of forest resources across all ownerships that can be used for planning and analyses at local, State, regional, and national levels. IWFIA uses a two-phase sampling procedure for all inventories. Phase one of the inventory is based on a grid of sample points systematically located every 1,000 meters across all lands in the State. Phase one points are assigned ownership and vegetative cover attributes using maps and remotely sensed imagery. Field crews conduct phase two of the inventory on a subsample of the phase one points that occur on forest land. The sampling intensity is one field plot every 5,000 meters, or about every 3 miles. Phase two plots are stratified based on phase one ownership and vegetation information, and weights are assigned to each stratum based on the proportion of phase one points in that stratum.

Phase two plots were sampled using the mapped-plot design. There were 205 field plots on the Black Hills National Forest. Of these, 173 plots sampled only forest conditions, 22 sampled both forest and nonforest conditions, and 10 sampled only nonforest conditions. A total of 222 forest conditions were sampled on 195 plots that contain 188.6 forest and 6.4 nonforest condition proportions.

About the mapped-plot design—The mapped-plot design was adopted by Forest Inventory and Analysis (FIA) nationwide by 1995. Its predetermined, subplot layout uses boundary delineation, when necessary, to classify differing conditions. Most plots sample one forest condition. Therefore, delineating conditions is often not required.

Conditions were separated or mapped on differences in any of five attributes: forest/nonforest, forest type, stand-size class, stand origin, and stand density. The condition proportion is the fraction of plot area sampled on each condition. The sum of all condition proportions for a plot equals 1.00. Therefore, the number and relative size of plot conditions determines the weighted area (condition proportion multiplied by expansion factor) used for sample expansion.

Standard errors—The sample was designed to meet national standards for precision in State and regional estimates of forest attributes. Standard errors, which denote the precision of an estimate, are usually higher for smaller subsets of the data. Forest-level estimates and percent standard errors by land class or type of trees for various attributes are presented in table 3. Standard errors for other estimates are available upon request (see “For further information” section on the inside back cover).

Table 3—Percent standard error for area estimate on total forest land, and percent standard errors for estimates of net volume, net annual growth, and annual mortality for all trees and growing-stock trees (5.0 inches d.b.h. and greater) on total forest land, Black Hills National Forest.

Land class or type of trees	Attribute	Area or volume	Percent standard error
Total forest land (acres)	Area	1,150,627	±1.6
All trees (cubic feet)	Volume	1,658,818,667	±4.9
	Growth	37,865,032	±6.3
	Mortality	5,233,754	±29.0
Growing-stock trees (cubic feet)	Volume	1,645,103,073	±4.9
	Growth	37,207,277	±6.4
	Mortality	5,223,144	±29.0

Photo by Blaine Cook

Documentation

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For further information

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Selected data for this Forest are part of a national data base that houses information for much of the forest land in the United States. This data base can be accessed on the Internet at the following Web site:

http://www.ncrs.fs.fed.us/4801/fiadb/index.htm

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Studies accelerate solutions to problems involving ecosystems, range, forests, water, recreation, fire, resource inventory, land reclamation, community sustainability, forest engineering technology, multiple use economics, wildlife and fish habitat, and forest insects and diseases. Studies are conducted cooperatively, and applications may be found worldwide.