USDA United States Department of Agriculture

Forest Service

Rocky Mountain Research Station

August 2004

Forest Resources of the Carson 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 its national Forest Inventory and Analysis (FIA) duties, conducted forest resource inventories of the Southwestern Region (Region 3) National Forests. This report presents highlights of the Carson National Forest 1998 inventory, including population estimates and summaries of commonly requested variables. Any trends or disturbances (such as fire) that have occurred since 1998 will be discussed in future reports of the Carson National Forest.

The information presented in this report is based solely on the IWFIA inventory sample (USDA 1998a). The data could be summarized in other ways for different purposes (see "For further information" on the inside back cover for the national FIA database and related contacts). Supplemental documentation and inventory terminology can be found in USDA (2002a), O'Brien (2002), or on the World Wide Web at http://www.fs.fed.us/rm/ogden. Changes in terminology or procedures may limit comparisons with previous estimates and summaries for this area. Additional data collected for the Carson National Forest, used separately or in combination with IWFIA data, may produce varying results.

Description of the Forest

The Carson National Forest administers 1,491,485 acres (USDA 1998b) of which 87 percent is classified as forest land and 13 percent nonforest. This report describes the characteristics of the forest land sampled on the Carson. Forest land is land that is at least 10 percent stocked (or formerly stocked) with live tally tree species and is greater than 1 acre in size and 120 feet wide. Based on the tree species present, forest land can be further subdivided into two land categories: timberland and woodland (fig. 1). Timberland is forest land with mostly timber species that are typically used in the wood products industry, such as ponderosa pine, aspen, and Douglas-fir. Woodland is forest land with mostly woodland species that often have a multistem growth form and are not typically used for industrial wood products, such as pinyon pine, junipers, and Gambel oak. On the Carson, 63 percent of the total forest land is timberland while 37 percent is woodland.

Just over four percent of the total forest land area administered by the Carson is reserved land, such as wilderness areas, that has been withdrawn from management for production of wood products. The first section of this report presents summaries of timber and woodland species for all forest land, including reserved designations. The subsequent section addresses nonreserved lands only and includes estimates for timber species sampled on the Carson.

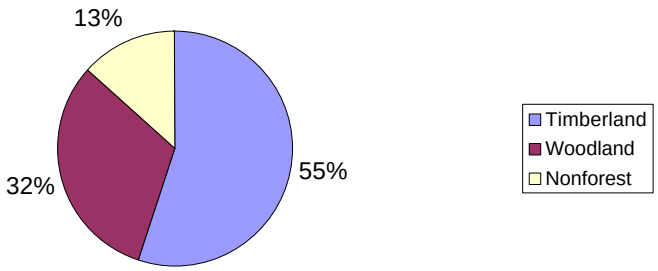


Figure 1—Percent of total area by land category, Carson National Forest.

Total forest land: highlights of our inventory

Forest type—Forest resources are often described using a forest type classification. Forest type refers to the prevalant 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.

Figure 2 presents the distribution of forest land area on the Carson by forest type. The pinyon-juniper forest type is the most common forest type, comprising 29 percent of the total forest land area. Pinyon-juniper is followed in abundance by ponderosa pine at 18 percent, aspen at 14 percent, and Douglas-fir at 11 percent. Spruce-fir, white fir, and deciduous woodland oak forest types each comprise about 7 percent of the total forest land area, with Engelmann spruce comprising just over 4 percent. The remaining 3 percent is made up of pure juniper, blue spruce, and foxtail/bristlecone pine forest types, each with about 1 percent of the total forest land area.

A field plot may sample more than one condition (stand). 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. Table 1 presents the number of conditions and the condition proportions sampled on the Carson National Forest by forest type for 211 plots that contained at least one forest condition.

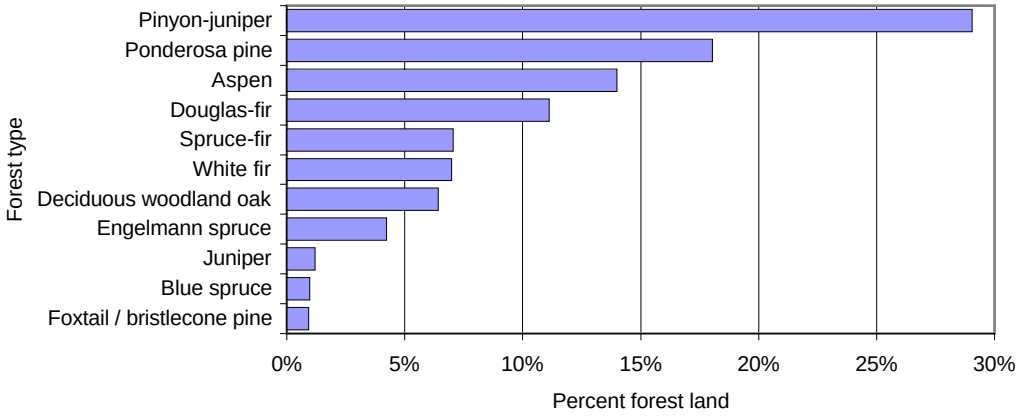


Figure 2—Percent of total forest land area by forest type, Carson National Forest.

Table 1—Number of conditions and condition proportions on forest land by forest type and land category, Carson National Forest, 1998.

Forest type	Number of conditions[a]	Condition proportions[b]
Timberland		
Ponderosa pine	39	36.5
Aspen	33	28.5
Douglas-fir	23	22.6
Spruce-fir	16	15.0
White fir	15	14.3
Engelmann spruce	9	9.0
Blue spruce	2	2.0
Foxtail/bristlecone pine	2	2.0
Total Timberland	**139**	**129.9**
Woodland		
Pinyon-juniper	62	57.6
Deciduous woodland oak	14	12.8
Juniper	4	2.4
Total Woodland	**80**	**72.8**
Grand Total	**219**	**202.7**

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

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

Number of live trees—Forest land can also be examined by looking at the composition of tree species. Figure 3 shows total number of live trees for all sampled tree species on the Carson for three diameter classes. Gambel oak makes up the plurality of live trees at 33 percent, with the vast majority of these less than 5 inches in diameter. Aspen and common or twoneedle pinyon each make up 12 percent of the live trees on the Carson. Corkbark fir and Engelmann spruce each make up 8 percent, and Douglas-fir makes up 7 percent. Ponderosa pine and white fir each made up 6 percent, oneseed juniper 4 percent, and Rocky Mountain juniper 2 percent. The rest of the live trees, found in more limited amounts on the Carson, are grouped into the other timber species and other woodland species categories. Other timber species make up 2 percent of the live trees on the Carson and include blue spruce, Rocky Mountain bristlecone pine, limber pine, and subalpine fir. Other woodland species make up 1 percent and include Rocky Mountain maple and alligator juniper. Species that are scarce may not be encountered with the extensive sampling strategy used for this inventory.

Number and weight of dead trees—Standing and down dead trees are important to forest ecosystems because they provide habitat for many species of wildlife, function as nutrient sinks, and protect the soil from erosion. Approximately 72.5 million standing dead trees (snags) and 58.1 million down dead trees (1 inch diameter and greater) are on Carson forest land, with 56.1 snags per acre. Different size snags provide habitat components for many wildlife species. Figure 4 shows the number of snags by forest type for three diameter classes. Of the total numbers of snags,

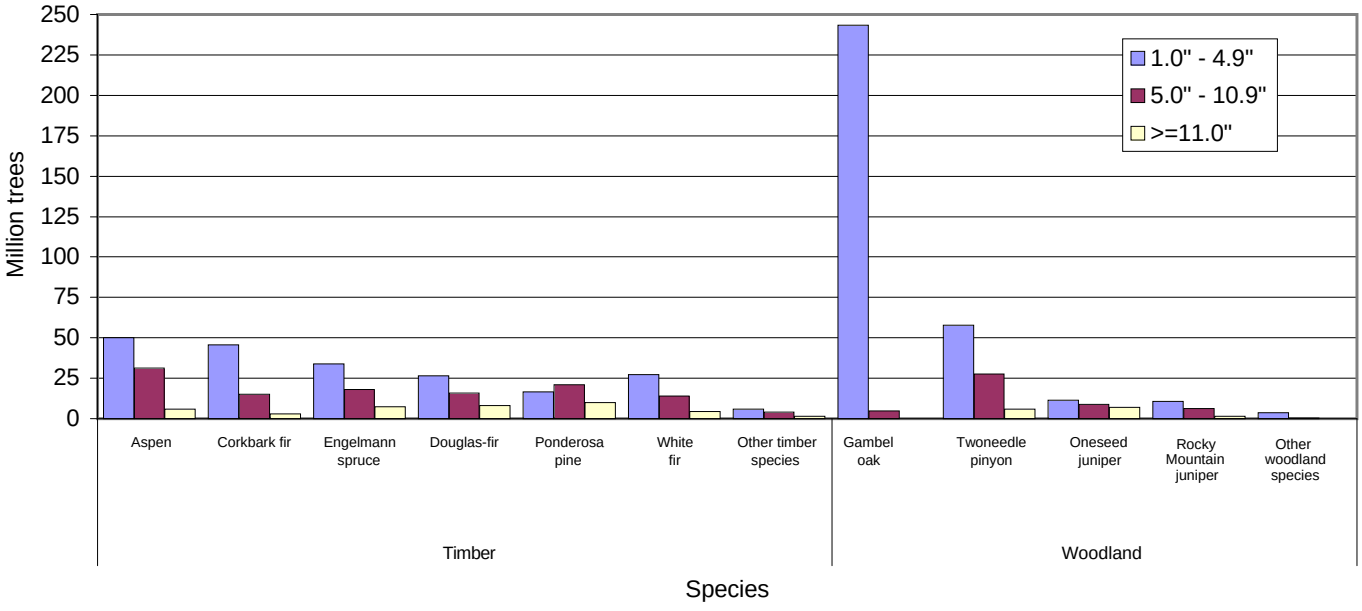


Figure 3—Number of live trees 1.0 inch diameter and greater on forest land by species and diameter-size class, Carson National Forest.

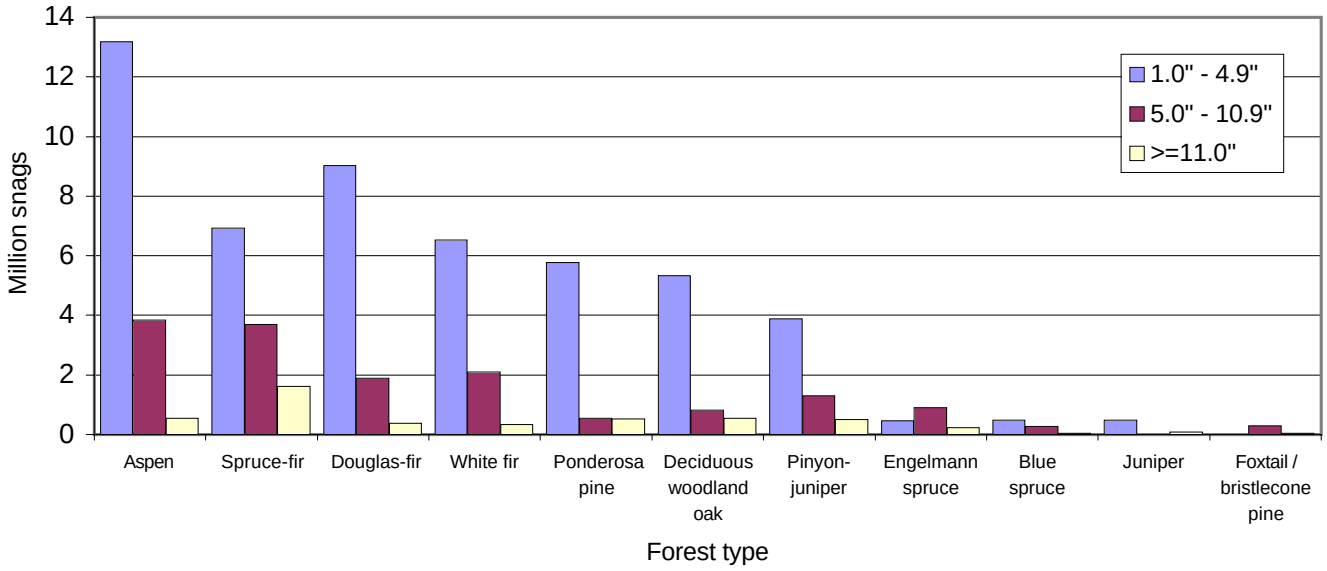


Figure 4—Number of standing dead trees 1.0 inch diameter and greater on forest land by forest type and diameter-size class, Carson National Forest, 1998.

72 percent are between 1 inch and 4.9 inches diameter, with over two-thirds of these occurring within the aspen (25 percent), Douglas-fir (17 percent), spruce-fir, and white fir (13 percent each) forest types. Of the total numbers of snags, 22 percent are between 5 and 10.9 inches diameter, with approximately half of these occurring within the aspen (25 percent) and spruce-fir (24 percent) forest types. Snags 11 inches diameter or larger make up 7 percent of the total, with 3.8 snags per acre. One third of these large snags are found on the spruce-fir forest type; the aspen, ponderosa pine, deciduous woodland oak, and pinyon-juniper forest types each comprise 11 percent.

The amount of dead material can contribute significantly to forest fuel loads and fire potential. Approximately 2.9 million tons of down dead trees and 2.6 million tons of standing dead trees are on Carson forest land, with 2.3 tons of down dead trees per acre. This estimate includes the merchantable bole and bark of trees 5 inches diameter and greater. Of the species contributing to down dead trees, more than one-quarter are aspen. Ponderosa pine (20 percent), Engelmann spruce (19 percent), and corkbark fir (11 percent) comprise half.

Tree and stand size—The size distribution of trees is an indicator of structural diversity. Figure 5 displays the number of live trees by 2-inch diameter class on the Carson, combining trees from all stands. Overall, this shows a typical diameter distribution with a higher number of small trees than large trees.

Stand-size class is a categorization of forest land based on the predominant diameter-size of live trees that contribute to the stocking of a stand. Stocking values for each stand are generally summed by the following diameter

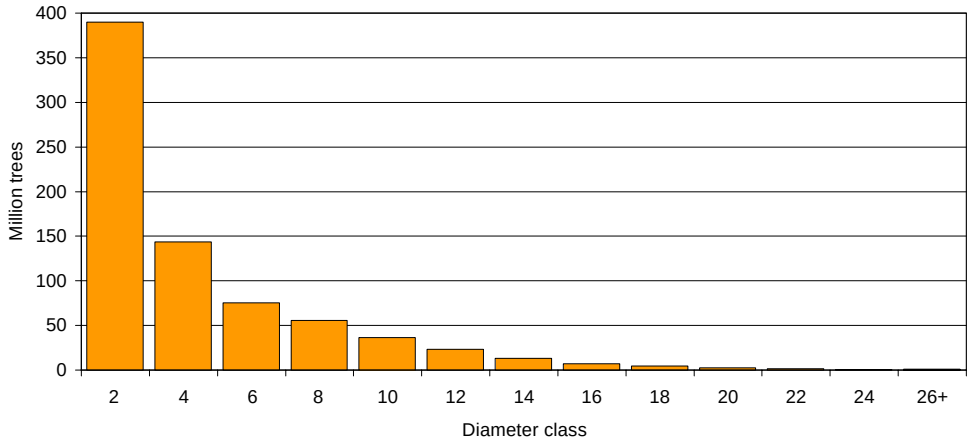


Figure 5—Number of live trees on forest land by 2-inch diameter class, Carson National Forest, 1998.

classes. The large diameter class includes softwoods 9 inches diameter and greater and hardwoods 11 inches diameter and greater; the medium diameter class includes softwoods 5 to 8.9 inches diameter and hardwoods 5 to 10.9 inches diameter; and the saplings/seedlings class includes all trees under 5 inches diameter. Then each stand (condition) is assigned a class according to stocking predominance. In terms of stocking, fewer large-diameter trees compared to small-diameter trees are required to fully utilize a site; therefore, large-diameter trees have a greater impact on determining stand-size class. Figure 6 displays forest land area on the Carson by stand-size class. Approximately 66 percent of the stands have a plurality of stocking of large trees, 17 percent of medium trees, and 12 percent of saplings and seedlings. About 5 percent are nonstocked, such as stands that have been recently harvested or burned .

Wood volume, biomass, and basal area of live trees—In general, estimates of volume, basal area, and biomass describe the amount of wood fiber in the forest. Each estimate summarizes different portions of a tree and are therefore more appropriate for different forest resource applications. For example, volume relates closely to wood as a product, basal area to forest or tree density, and biomass to forest or tree productivity. In table 2, volume represents the amount of wood fiber in the merchantable bole of a tree, while biomass represents the amount of wood fiber in terms of oven-dry weight including the bole, bark, and branches of the tree. Basal area estimates include the cross-sectional area of a tree stem/bole at the point

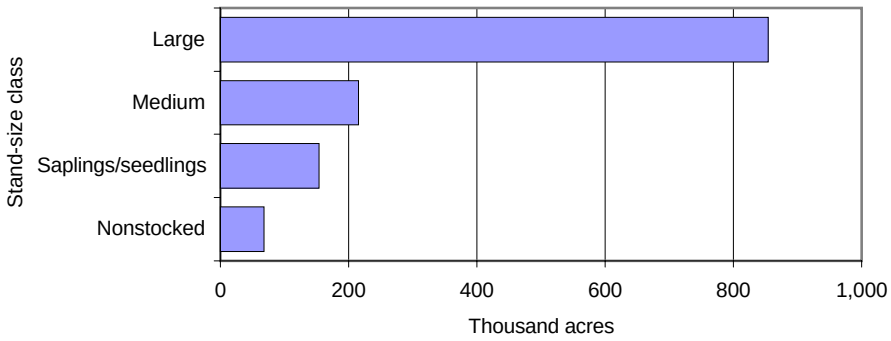


Figure 6—Forest land area by stand-size class, Carson National Forest. Large trees include softwoods 9.0"+ and hardwoods 11.0"+; medium trees include softwoods 5.0" to 8.9" and hardwoods 5.0" to 10.9"; saplings/seedlings include trees <5.0".

Table 2—Net volume, biomass, and basal area on forest land by species, Carson National Forest, 1998.

Species	Volume (million cubic-feet)	Biomass (million tons)	Basal area (million square ft.)
Ponderosa pine	347.6	6.9	19.5
Aspen	336.4	5.8	16.1
Engelmann spruce	326.6	5.1	14.8
Douglas-fir	313.4	6.2	16.5
Twoneedle pinyon	170.7	2.0	14.5
Corkbark fir	137.2	2.2	7.2
White fir	137.1	2.6	9.2
Oneseed juniper	76.6	1.0	12.2
Rocky Mountain juniper	30.1	0.4	4.0
Blue spruce	23.4	0.4	1.2
Rocky Mountain bristlecone pine	15.1	0.3	1.2
Gambel oak	8.7	0.3	1.1
Limber pine	8.0	0.1	0.5
Rocky Mountain maple	1.5	†	0.2
Subalpine fir	0.5	†	‡
Alligator juniper	0.4	†	‡
Total (all tree species)	**1,933.3**	**33.3**	**118.2**

† Less than 100,000 tons
‡ Less than 100,000 sq ft

where diameter is measured. Table 2 shows a breakdown by species of net volume, biomass, and basal area for live trees 5 inches diameter and larger on the Carson. Ponderosa pine, aspen, Engelmann spruce, and Douglas-fir together make up the majority of volume (68 percent total) and biomass (72 percent total), and account for over half the basal area (57 percent). Although abundant in numbers (see fig. 3), Gambel oak accounts for relatively little volume or biomass because most trees of that species are below 5 inches in diameter.

Figure 7 shows the distribution of net volume of wood in trees by 2-inch diameter class on Carson forest land. While the number of trees declines with larger diameter classes (see fig. 5), the volume increases significantly from diameter class 6 to 12 inches, where net volume peaks.

Another way to look at wood volume is by forest type, for which per acre estimates can be computed along with biomass and basal area (table 3). These numbers include the many different species that can occur together within each forest type. The highest volume per acre on the Carson is in the spruce-fir forest type, followed by blue spruce and Douglas-fir. These three forest types also contain the highest basal area and biomass per acre, because these attributes are strongly correlated with volume.

Many of the forest types listed in table 3 may not be representative due to small sample sizes (see table 1). Only the pinyon-juniper, aspen, ponderosa pine, and Douglas-fir forest types have large samples.

Stand density index—Many factors influence the rate at which trees grow and thrive, or die. As tree size and density

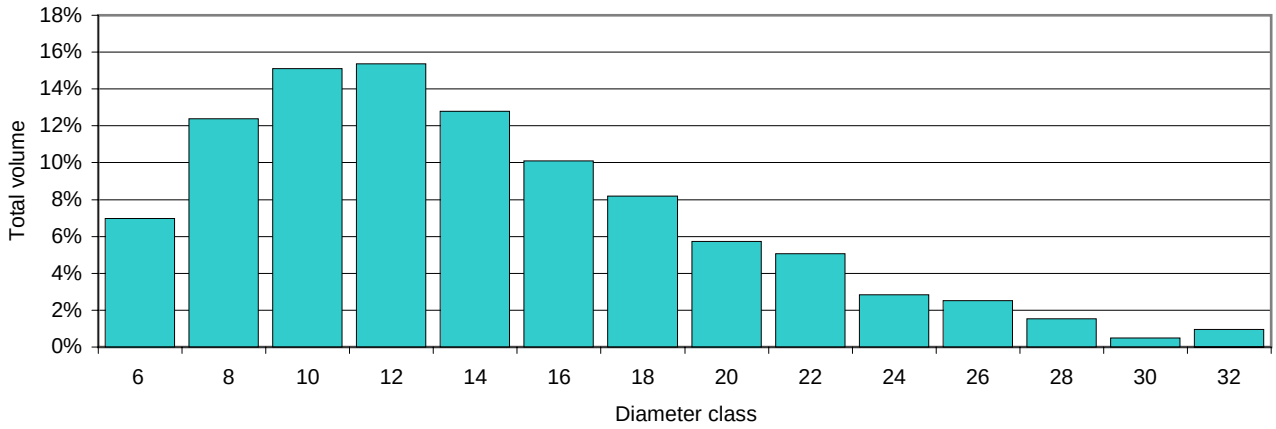


Figure 7—Percent of total net cubic-foot volume of live trees by 2-inch diameter class, Carson National Forest.

Table 3—Net volume, biomass, and basal area per acre on forest land by forest type, Carson National Forest, 1998.

Forest type	Volume cubic ft. per acre	Biomass tons per acre	Basal area square ft. per acre
Spruce-fir	3,796	58.6	164
Blue spruce	2,895	47.6	133
Douglas-fir	2,093	40.1	112
Aspen	1,987	35.1	104
Engelmann spruce	1,796	29.4	98
White fir	1,654	31.9	100
Ponderosa pine	1,355	26.5	80
Foxtail/bristlecone pine	897	17.1	72
Pinyon-juniper	762	10.1	80
Deciduous woodland oak	320	6.7	25
Juniper	267	3.5	44
Total (all types)	**1,496**	**25.8**	**91**

increase, competition for available resources increases. Stand density index (SDI), as developed by Reineke (1933), is a relative measure quantifying the relationship between trees per acre, stand basal area, average stand diameter, and stocking of a forested stand. The concept was developed for even-aged stands, but can also be applied to uneven-aged stands (Long and Daniel 1990; see next paragraph for an explanation of even-aged and uneven-aged stands). SDI is usually presented as a percentage of the maximum SDI for each forest type (USDA 1991). SDI was computed for each location using those maximums, and the results were grouped into six classes (fig. 8). A site is considered to be fully occupied at 35 percent of SDI maximum, which marks the onset of competition-related stresses and slowed growth rates (USDA 1991). Based on FIA sample data, 55 percent of all forest stands in the Carson National Forest are considered to be fully occupied.

Southwest stand structure—Stands may be categorized on the basis of tree size, often in terms of their prevalent diameter or height class. This works well for stands where just one or two size classes dominate. Such stands are called single-storied, or even-aged, because they have a structure characterized by a single canopy layer or two closely related layers. Stands having a structure composed of three or more size classes are called multistoried or uneven-aged stands. Both types of structure are important in forest diversity. Differences between single-storied stands provide structural diversity across a landscape. Differences between many layers within a multistoried stand provide vertical diversity.

Figure 9 shows area of forest land by stand structure class and diameter class for three timber softwood forest type groups including pine, mixed conifer, and spruce-fir timber softwood types. On the Carson, the pine category

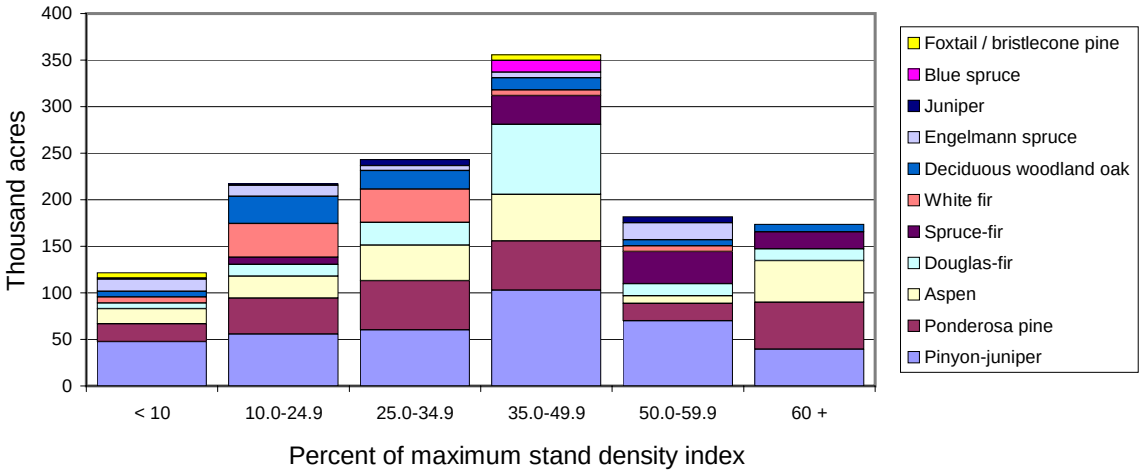


Figure 8—Area of forest land by forest type and percent stand density index, Carson National Forest.

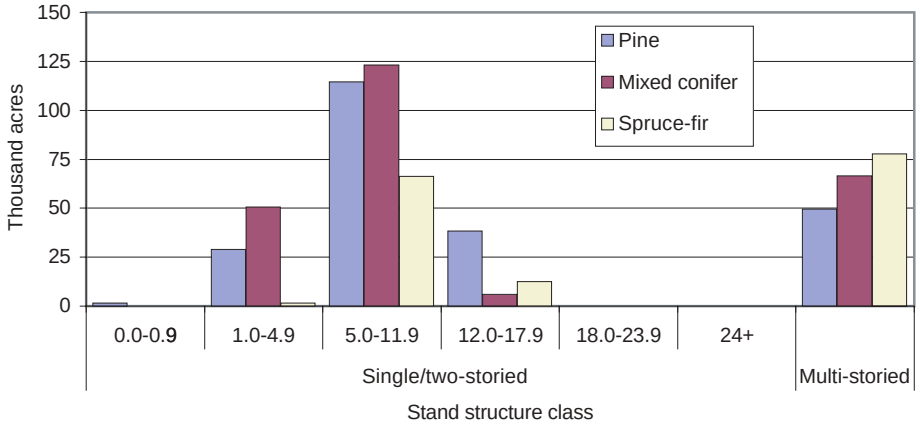


Figure 9—Area of forest land by stand structure class, diameter class, and timber softwood forest type groups, Carson National Forest.

is made up of the ponderosa pine forest type; the mixed conifer category includes the Douglas-fir, blue spruce, and white fir forest types; and the spruce-fir category contains the spruce-fir, Engelmann spruce, and foxtail/bristlecone pine forest types. The values shown are based on analysis of SDI and tree diameter classes, a method developed by the Southwest Region (USDA 2002b). In general, the Carson is represented by both single-storied and multistoried stands, with about two-thirds of the single-storied stands occurring in the 5 to 11.9 inch diameter class.

Growth and mortality—Forest vigor can be analyzed by measures of net annual growth and mortality. Net annual growth is the difference between gross annual growth and losses due to mortality. Gross annual growth is the average annual increase in the volume of live trees while mortality is the net volume of trees that have died over a 1-year period based on a 5-year average. Gross annual growth of all live trees 5 inches diameter and greater on all forest land on the Carson is estimated to be 38 million cubic feet. Subtracting mortality results in an estimated net annual growth of 27 million cubic feet.

Mortality calculations estimate approximately 11 million cubic feet of wood 5 inches diameter and greater died on the Carson in 1997. Ponderosa pine has the highest proportion of total mortality volume at 34 percent; with aspen at 24 percent, corkbark fir at 13 percent, and Engelmann spruce at 11 percent. Douglas-fir makes up 8 percent of total mortality volume, and white fir 7 percent. Blue spruce, Rocky Mountain juniper, and twoneedle pinyon combine to make the remaining 2 percent of mortality volume on Carson forest land. Based on field observations, 33 percent of the mortality on the Carson was caused by disease, 27 percent by fire, 27 percent by insects, and nearly 10 percent by weather-related stresses. The remaining 3 percent was attributed to suppression and unknown causes.

Figure 10 compares gross annual growth to mortality for the nine species that included mortality trees. The largest mortality-to-growth ratio occurs in ponderosa pine, where mortality volume is half the gross growth. Most of the ponderosa pine mortality occurs in the deciduous woodland oak forest type, where ponderosa pine is fairly common. In the deciduous woodland oak forest type, ponderosa pine mortality volume is several times its gross growth, yielding negative net growth for ponderosa pine there. Mortality volume in both corkbark fir and aspen is about one-third of the gross growth on all forest land. All species show positive net growth on all forest land.

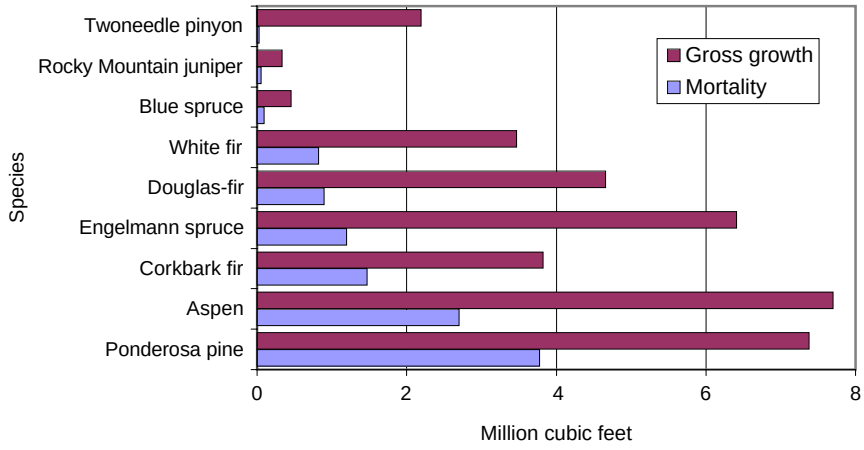
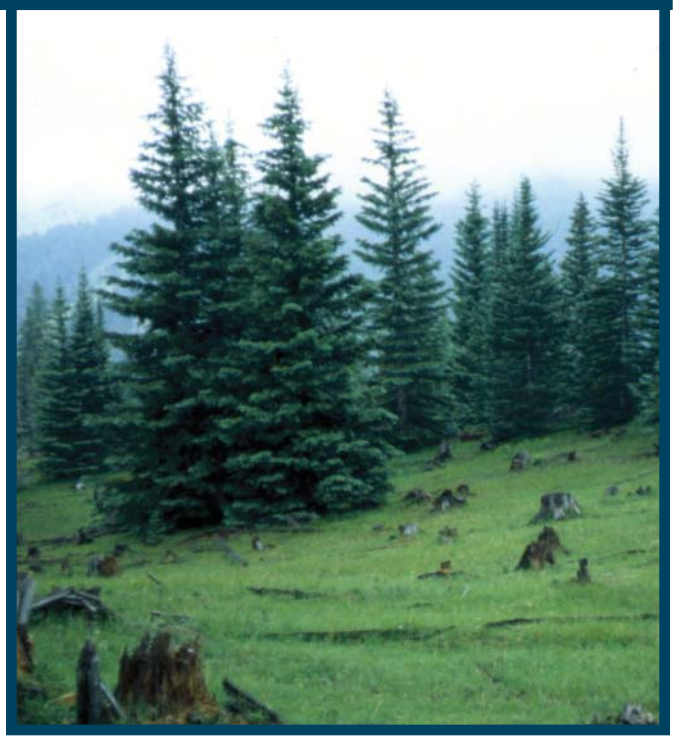


Figure 10—Gross annual growth of live trees 5.0 inches diameter and greater compared to mortality on all forest land, Carson National Forest.

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 1998a for details). Figure 11 shows the average percent cover of plant groups on forest land by forest type. Some forest types, for example blue spruce and foxtail/bristlecone pine, are based on relatively small samples (see table 1).



Nonreserved timberland: highlights of our inventory

Tree and stand size—Almost 59 percent of forest land in the Carson National Forest is nonreserved timberland. The area of nonreserved timberland by stand-size class is presented in figure 12. Similar to all forest land in the Carson

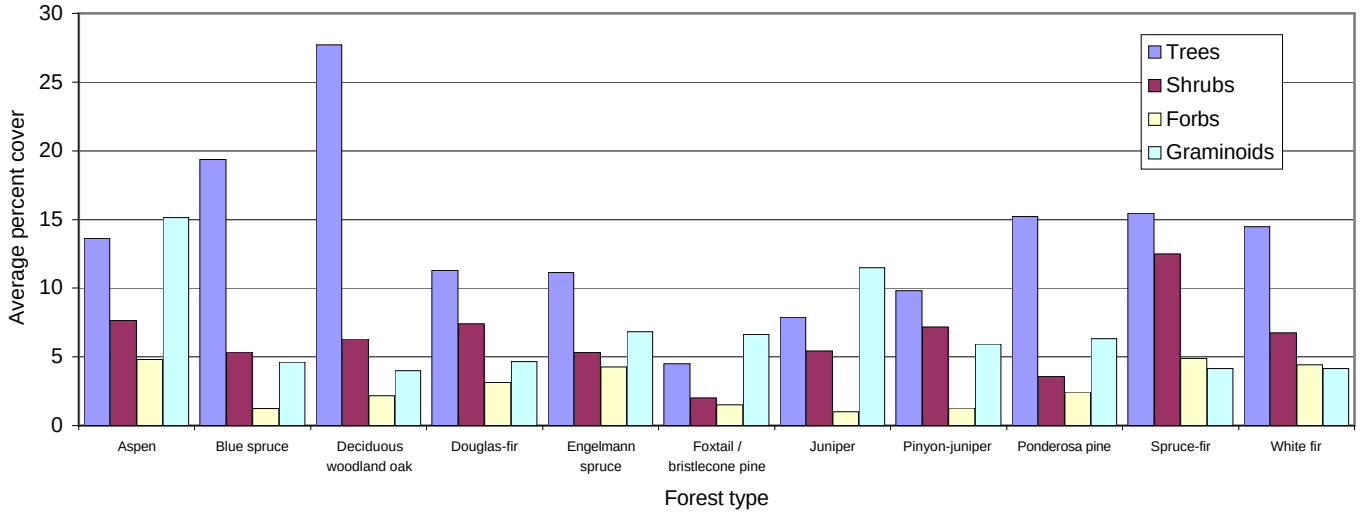


Figure 11—Average percent cover of trees (seedlings/saplings), shrubs, forbs, and graminoids on forest land by forest type,Carson National Forest.

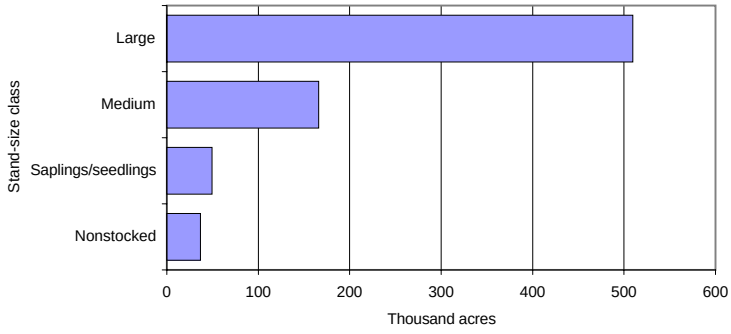


Figure 12—Area of nonreserved timberland by stand-size class, Carson National Forest.

(see fig. 6), most of the nonreserved timberland area has a plurality of stocking from large trees.

Figure 13 shows the number of growing-stock trees by 2-inch diameter class on nonreserved timberland on the Carson. Growing-stock trees are live timber species meeting specific standards of quality and vigor. Of all growing-stock trees on nonreserved timberland on the Carson, 18 percent are 9 inches diameter or greater.

Wood volume, biomass, and basal area of growing-stock trees—Table 4 displays a breakdown of net cubic-foot volume, tons of wood biomass, and square foot basal area for growing-stock trees 5 inches diameter and greater by species on nonreserved timberland for the Carson. The total net cubic-foot volume of growing stock on nonreserved timberland is over 1.4 billion cubic feet. Together, ponderosa pine, Douglas-fir, aspen and Engelmann spruce account for 80 percent of this volume. The total wood biomass is estimated at 25.3 million tons, with ponderosa pine, Douglas-fir, aspen and Engelmann spruce combining to make up 81 percent of this amount. Total basal area for growing-stock trees on nonreserved timberland is estimated at 73.8 million square feet, with the combination of ponderosa pine, Douglas-fir, aspen and Engelmann spruce comprising 77 percent of this total.

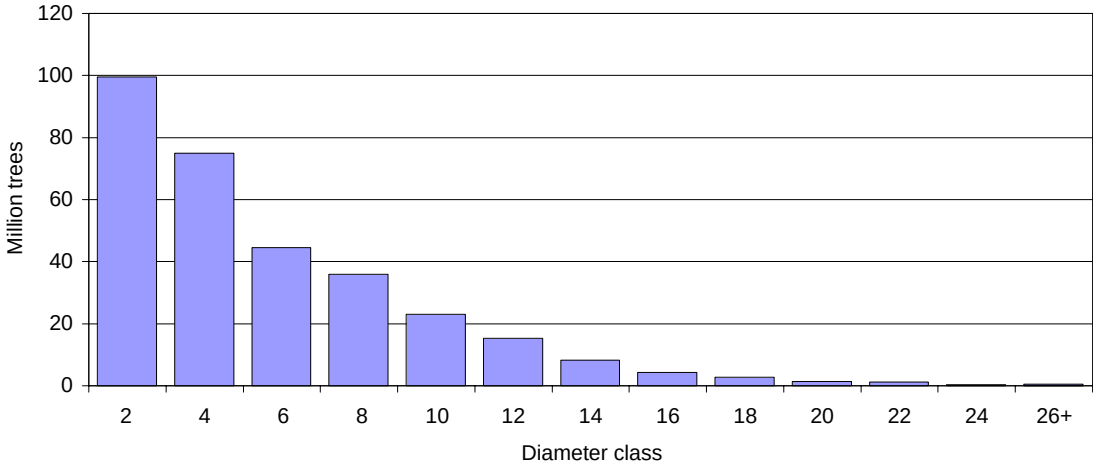


Figure 13—Number of growing-stock trees on nonreserved timberland by 2-inch diameter class, Carson National Forest.

Table 4—Net volume, biomass, and basal area of growing-stock trees 5 inches diameter and greater on forest land by species on nonreserved timberland, Carson National Forest, 1998.

Species	Volume (million cubic feet)	Biomass (million tons)	Basal area (million square feet)
Ponderosa pine	307.3	6.0	17.0
Douglas-fir	301.8	5.9	15.9
Aspen	288.1	4.9	13.6
Engelmann spruce	236.0	3.7	10.7
White fir	119.2	2.3	8.1
Corkbark fir	109.4	1.8	5.9
Blue spruce	23.3	0.4	1.2
Rocky Mountain bristlecone pine	13.7	0.3	1.0
Limber pine	7.3	0.1	0.5
Subalpine fir	0.5	†	‡
Total*	**1,406.8**	**25.3**	**73.8**

† less than 100,000 tons
‡ less than 100,000 square feet
* numbers do not add to total due to rounding

The total net sawtimber volume on nonreserved timberland is estimated at 4.5 billion board feet (Scribner rule).

Sawtimber includes all growing-stock trees 9 inches and greater for softwoods, and 11 inches diameter and greater for hardwoods. Seventy percent of this volume consists of ponderosa pine (1.2 billion board feet), Douglas-fir (1.1 billion board feet), and Engelmann spruce (0.8 billion board feet).

Growth and mortality—Gross annual growth of growing-stock trees on nonreserved timberland on the Carson is estimated to be 29.3 million cubic feet, while mortality is estimated at 7.1 million cubic feet. This calculates to a net annual growth of 22.2 million cubic feet. Mortality volume was attributed to seven species, with over half of this total being in aspen (37 percent) and corkbark fir (21 percent). Gross annual growth is compared to mortality for these seven species in figure 14. Mortality for nonreserved timberland on the Carson is about 24 percent of gross annual growth, with relatively large mortality-to-growth ratios occurring in corkbark fir and aspen. One notable difference between these results and those shown in figure 10 is the lower mortality-to-growth ratio for ponderosa pine on nonreserved timberland. Mortality volume in ponderosa pine is one-eighth of its gross annual growth on nonreserved timberland, compared to one-half live ponderosa pines 5 inches diameter or greater on all forest land.

The inventory methods

About the two-phase sample design—FIA inventories provide 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 (for further information about the national FIA program, refer to the World Wide Web at http://www.fia.fs.fed.us). 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 (approximately one sample point per 247 acres) 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 (approximately one field plot per 6,178 acres), 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 235 field plots on the Carson National Forest, of which one was determined to be inaccessible. A total of 191 field plots sampled only forest conditions, 20 sampled both forest and nonforest conditions, and 23 sampled only nonforest conditions. A total of 219 forest conditions (stands) were sampled on 211 plots that contain 202.7 forest and 8.3 nonforest condition proportions.

About the mapped-plot design—The mapped-plot design was adopted by Forest Inventory and Analysis nationwide by 1995. The predetermined subplot layout uses boundary delineation, when necessary, to classify differing conditions. Most plots sample a single 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

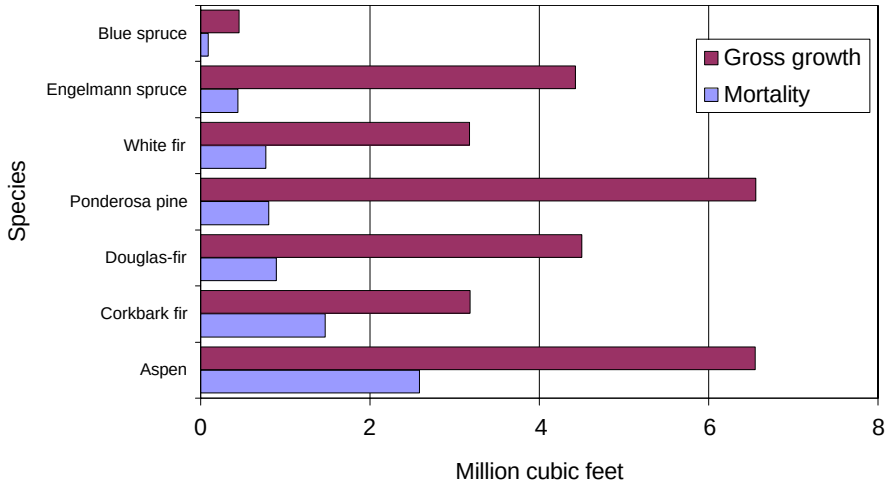


Figure 14—Gross annual growth of growing-stock trees 5.0 inches diameter and greater compared to mortality on nonreserved timberland, Carson National Forest.

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 two-phase sampling scheme 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 data. Percent standard errors for estimates of area, net volume, net annual growth and annual mortality are presented in table 5. Standard errors for other estimates are available upon request (see "For further information" section on the inside back cover).

Table 5—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 on total forest land, and growing-stock trees on nonreserved timberland (5 inches diameter and greater), Carson National Forest.

Land class	Attribute	Estimate	Percent standard error
Total forest land (acres)	Area	1,292,187	±2.3
Total forest land (all trees cubic feet)	Volume	1,933,282,045	±6.2
	Growth	26,839,467	±15.0
	Mortality	11,059,381	±32.3
Nonreserved timberland (acres)	Area	761,669	±5.5
Nonreserved timberland (growing-stock trees cubic feet)	Volume	1,406,792,990	±8.3
	Growth	22,201,490	±9.9
	Mortality	7,054,301	±25.5

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Selected data for this Forest are part of a national database that houses information for much of the forest land in the United States. This database 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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