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Forest Resources of the Santa Fe National Forest

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About the author

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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 Santa Fe National Forest 1998 inventory including population estimates and summaries of commonly requested variables. Any trends or disturbances (such as fire) that have occurred after 1998 will be discussed in future reports of the Santa Fe 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 Santa Fe National Forest, used separately or in combination with IWFIA data, may produce varying results.



Description of the Forest

The Santa Fe National Forest administers 1,570,857 acres (USDA 1998b) of which 93 percent is classified as forest land and 7 percent nonforest. This report describes the characteristics of the forest land sampled on the Santa Fe. 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 typically used in the wood products industry, such as ponderosa pine 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 oaks. On the Santa Fe, 64 percent of the total forest land is timberland while 36 percent is woodland.

Nineteen percent of the total forest land area administered by the Santa Fe is reserved land, meaning that it has been withdrawn from management for production of wood products, such as wilderness areas. 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 Santa Fe.

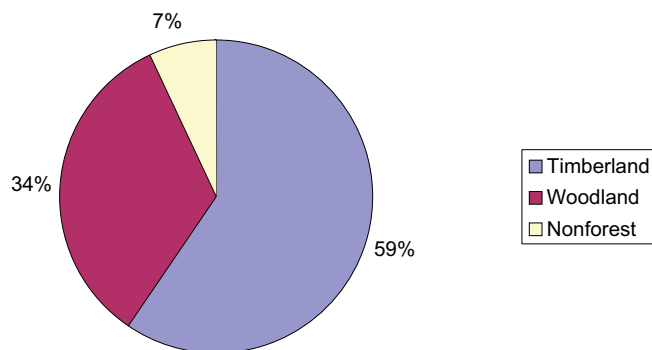


Figure 1—Percent of total area by land category, Santa Fe National Forest.

Total forest land: highlights of our inventory

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

Figure 2 presents the distribution of forest land area on the Santa Fe by forest type. The pinyon-juniper (29 percent) and ponderosa pine (23 percent) forest types comprise over half of the total forest land area. The remaining 48 percent comprises a variety of timber and woodland types including Douglas-fir, white fir, spruce-fir, Engelmann spruce, aspen, limber pine, blue spruce and cottonwood (timber forest types), and deciduous woodland oak and juniper (woodland forest types).

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 Santa Fe National Forest by forest type for 241 plots that contained at least one forest condition.

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 Santa Fe for three diameter classes. Gambel oak makes up the plurality of live trees at 38 percent with most of these less than 5 inches in diameter. Common, or two needle, pinyon makes up 13 percent, ponderosa pine and Douglas-fir 8 percent each; white fir, 7 percent; aspen, 6 percent; Engelmann spruce and oneseed juniper, 5 percent each; corkbark fir, 4 percent; limber pine, and Rocky Mountain juniper, 2 percent; and subalpine fir and blue spruce 1 percent each. The rest of the live trees, which are grouped in the other timber and other woodland categories, are found in limited amounts on the Santa Fe. Other timber

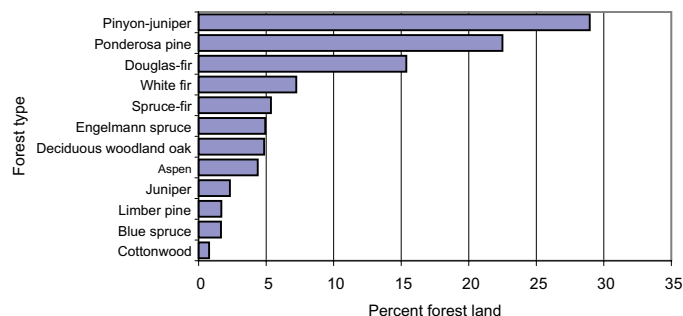


Figure 2—Percent of total forest land area by forest type, Santa Fe National Forest.

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

Forest type	Number of conditions ^a	Condition proportions ^b
Timberland		
Ponderosa pine	59	53.6
Douglas-fir	39	36.8
White fir	20	18.1
Aspen	14	10.7
Spruce-fir	13	12.5
Engelmann spruce	12	11.3
Blue spruce	5	3.8
Limber pine	4	4.0
Cottonwood	2	2.0
Total Timberland	168	152.9
Woodland		
Pinyon-juniper	76	67.1
Deciduous oak woodland	12	11.8
Juniper woodland	5	5.0
Total Woodland	93	83.9
Grand Total	261	*236.7

^aNumber 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.

^bSum 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 does not add to total due to rounding.



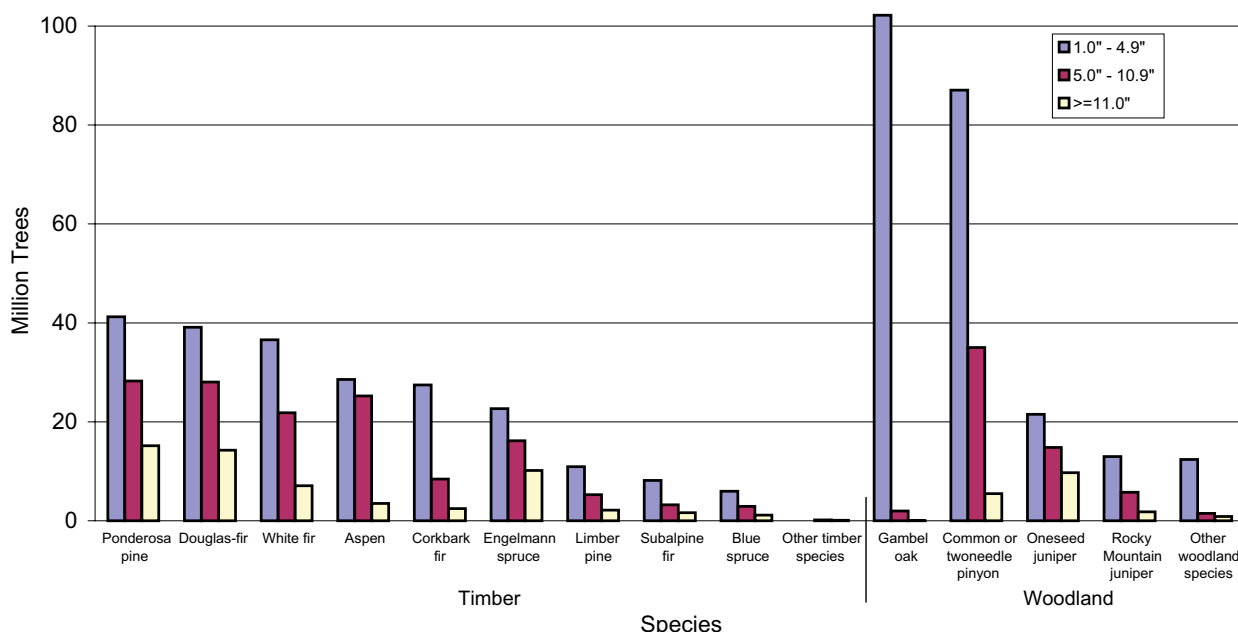


Figure 3—Number of live trees 1 inch diameter and greater on forest land by species and diameter-size class, Santa Fe National Forest. The 1-4.9 inch diameter class for Gambel oak was truncated to improve display (actual value is 378,722,571).

species includes narrowleaf, Fremont, and Rio Grande cottonwood. Other woodland species includes New Mexico locust, Rocky Mountain maple, Arizona white/gray oak, Utah juniper, Arizona pinyon, Rocky Mountain juniper, 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 126 million standing dead trees (snags) and 40 million down dead trees (1 inch diameter and greater) are on Santa Fe forest land, with 86 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, 78 percent are between 1 inch and 4.9 inches diameter, with nearly half of these occurring within the Douglas-fir

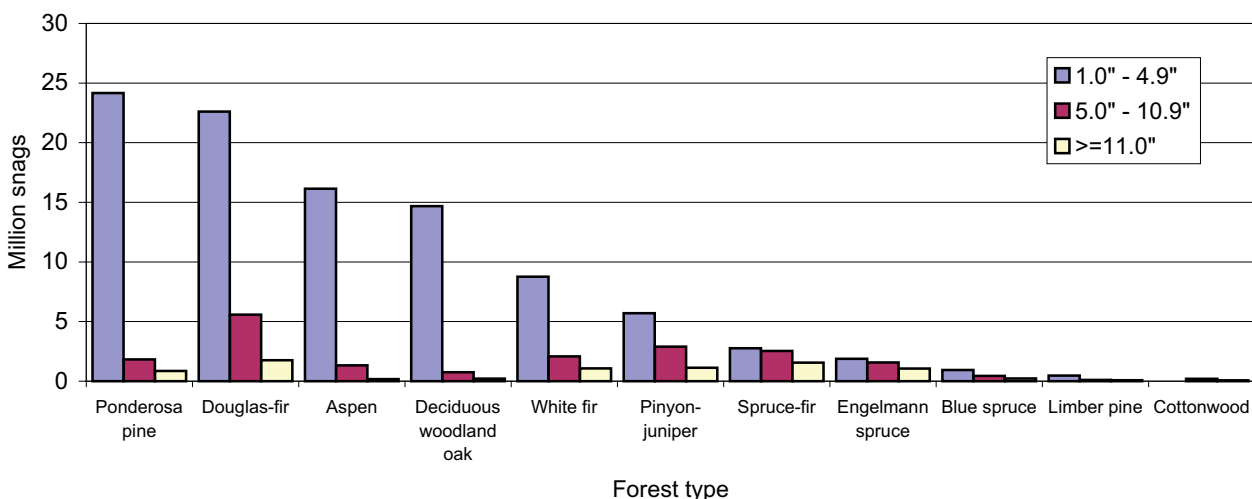


Figure 4—Number of standing dead trees 1 inch diameter and greater on forest land by forest type and diameter-size class, Santa Fe National Forest.

and ponderosa pine forest types combined. Of the total numbers of snags, 15 percent are between 5 and 10.9 inches diameter, with Douglas-fir having the most at 29 percent. Snags 11 inches diameter or larger make up 7 percent of the total, with 5.6 snags per acre. Most of these large snags are found on Douglas-fir (21 percent), spruce-fir (19 percent) and pinyon-juniper (14 percent) forest types.

The amount of dead material can contribute significantly to forest fuel loads and fire potential. Approximately 3.8 million tons of down dead trees and 4.3 million tons of standing dead trees are on Santa Fe forest land, with 2.6 tons of down dead trees per acre. This estimate includes the merchantable bole and bark of trees 5 inches diameter and greater. Ponderosa pine (26 percent), Engelmann spruce (22 percent), Douglas-fir (17 percent), and aspen (11 percent) comprises the majority of down dead material. Corkbark fir, subalpine fir, white fir, common or two needle pinyon, oneseed juniper, Rocky Mountain juniper, limber pine, blue spruce, and gambel oak combine to make the rest.

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 Santa Fe, combining trees from all stands. Overall, this shows a typical

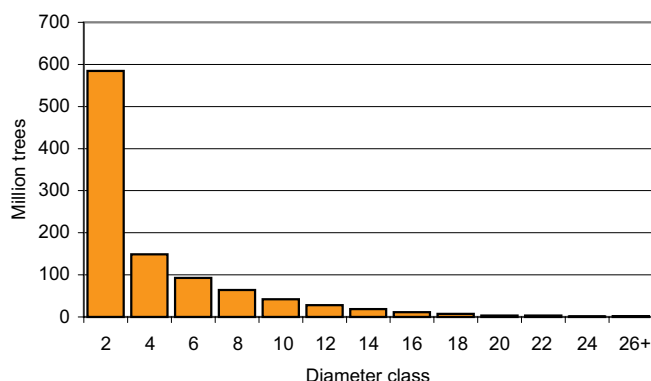


Figure 5—Number of live trees on forest land by 2-inch diameter class, Santa Fe National Forest.

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 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 Santa Fe by stand-size class. Approximately 79 percent of the stands have a

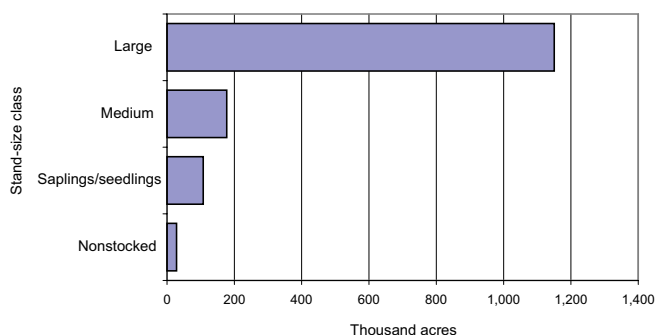


Figure 6—Forest land area by stand-size class, Santa Fe National Forest. large trees include softwoods 9 inches and greater and hardwoods 11 inches and greater; medium trees include softwoods 5 inches to 8.9 inches and hardwoods 5 inches to 10.9 inches; saplings/seedlings include trees less than 5 inches.

plurality of stocking from large trees and about 2 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 therefore, are more appropriate for various 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 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 Santa Fe. Douglas-fir makes up the most volume (22 percent), biomass (25 percent), and basal area (19 percent). Although abundant in numbers (see fig. 3), gambel oak accounts for 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 Santa Fe forest land. While the number of trees generally 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 Santa Fe is in the spruce-fir forest type, followed by the Engelmann spruce and blue spruce.

Many of the forest types listed in table 3 may not be representative due to small sample sizes (see table 1).

Stand density index—Many factors influence the rate at which trees grow and thrive, or die. As tree size and density 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). The “other” category contains cottonwood, blue spruce, limber pine, and juniper. A

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

Species	Volume (million cubic-feet)	Biomass (million tons)	Basal area (million square feet)
Douglas-fir	643.6	12.4	30.3
Ponderosa pine	557.8	10.9	28.9
Engelmann spruce	503.1	7.4	19.1
White fir	307.5	5.7	16.8
Aspen	224.6	4.1	11.0
Common or twoneedle pinyon	196.7	2.4	16.2
Corkbark fir	108.6	1.7	5.0
Oneseed juniper	89.9	1.1	17.9
Limber pine	79.9	1.4	4.5
Subalpine fir	73.0	1.1	3.1
Blue spruce	64.4	1.0	2.4
Rocky Mountain juniper	30.2	0.4	3.9
Utah juniper	4.4	†	1.0
Narrowleaf cottonwood	4.2	†	0.2
Other species*	8.6	0.2	1.0
Total** (all tree species)	2,896.5	49.8	161.3

† Less than 100,000 tons

*Other species include: Alligator juniper, Arizona white oak/gray oak, Fremont cottonwood, Rio Grande cottonwood, Gambel oak, Rocky Mountain maple, Arizona pinyon pine, and New Mexico locust

** Numbers do not add to total due to rounding

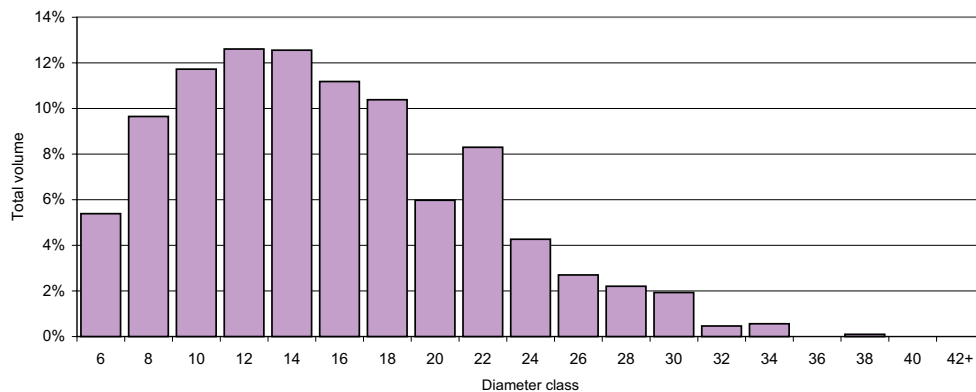


Figure 7—Percent of total net cubic-foot volume of live trees by 2-inch diameter class, Santa Fe National Forest.

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

Forest type	Volume (cubic feet per acre)	Biomass (tons per acre)	Basal area (square feet per acre)
Spruce-fir	5,223	79.3	205
Engelmann spruce	4,190	64.7	167
Blue spruce	3,721	60.5	140
Douglas-fir	3,379	63.0	157
Aspen	2,389	41.3	129
White fir	2,308	43.3	125
Limber pine	2,180	40.3	119
Ponderosa pine	1,592	31.2	87
Cottonwood	776	13.0	46
Pinyon-juniper	752	9.6	89
Deciduous woodland oak	364	7.3	29
Juniper	173	2.4	35
Total (all types)	1,979	34.0	110

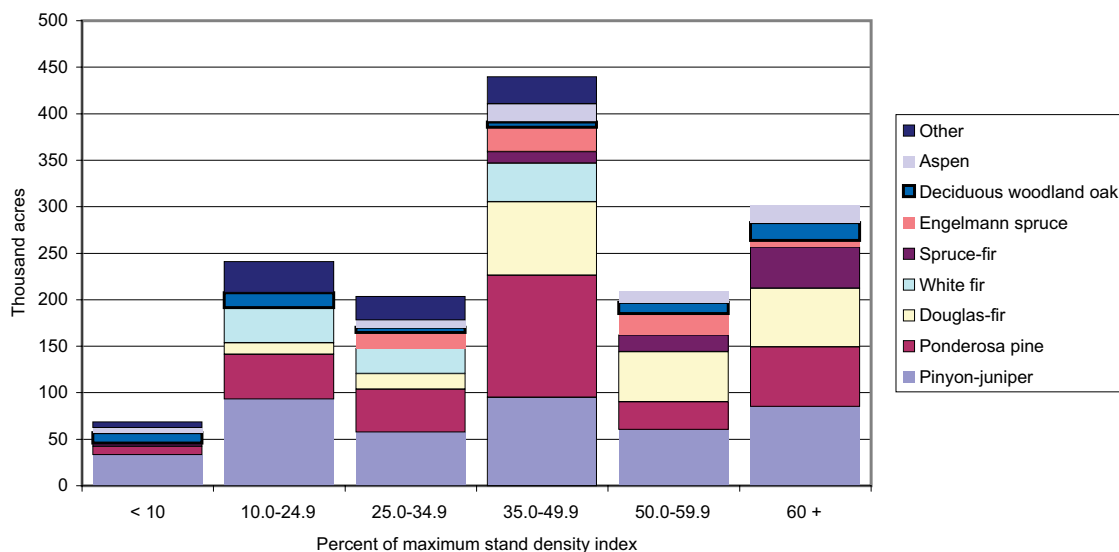


Figure 8—Area of forest land by forest type and percent stand density index, Santa Fe National Forest.

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, nearly 65 percent of all forest stands in the Santa Fe 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 predominant 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 “other” timber softwood types. On the Santa Fe, the pine category is made up of ponderosa pine, the mixed conifer category includes Douglas-fir, white fir, and blue spruce, and the “other” category contains miscellaneous softwoods including Engelmann spruce, spruce-fir, and limber pine. 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 Santa Fe is represented by both single-storied



and multistoried stands, but the distribution within single-storied stands occurs mainly 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 Santa Fe is estimated to be 55 million cubic feet. Subtracting mortality results in an estimated net annual growth of 45 million cubic feet.

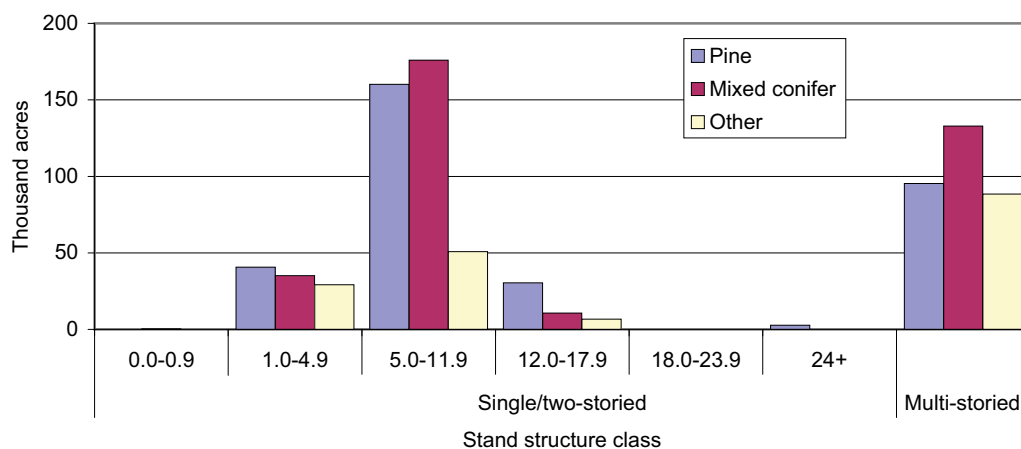


Figure 9—Area of forest land by stand-structure class, diameter class, and timber softwood forest type groups, Santa Fe National Forest.

Mortality calculations estimate approximately 10 million cubic feet of wood from trees 5 inches diameter and greater died on the Santa Fe in 1997. Douglas-fir makes up most of the total mortality volume at almost 31 percent with white fir at 20 percent, ponderosa pine at 17 percent, and Engelmann spruce at 11 percent. Corkbark fir, subalpine fir, blue spruce, limber pine, aspen, common or twoneedle pinyon, narrowleaf cottonwood, oneseed juniper, alligator juniper, and Rocky Mountain juniper combine to make 21 percent of the remaining mortality volume on Santa Fe forest land. Based on field observations, 30 percent of the mortality on the Santa Fe was caused by disease, 24 percent by fire, 21 percent by insects, and 8 percent by weather-related stresses. The remaining 17 percent was attributed to suppression and unknown causes.

Figure 10 compares gross annual growth to mortality for five out of the 14 species that included mortality trees. These species showed positive net growth. Out of the 14 species that did have mortality, only alligator juniper and narrowleaf cottonwood yielded negative net growth but have very small sample sizes.

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 1998b for details). Figure 11 shows the average percent cover of plant groups on forest land by forest type. Some forest types, for example cottonwood and limber pine, are based on relatively small samples (see table 1).

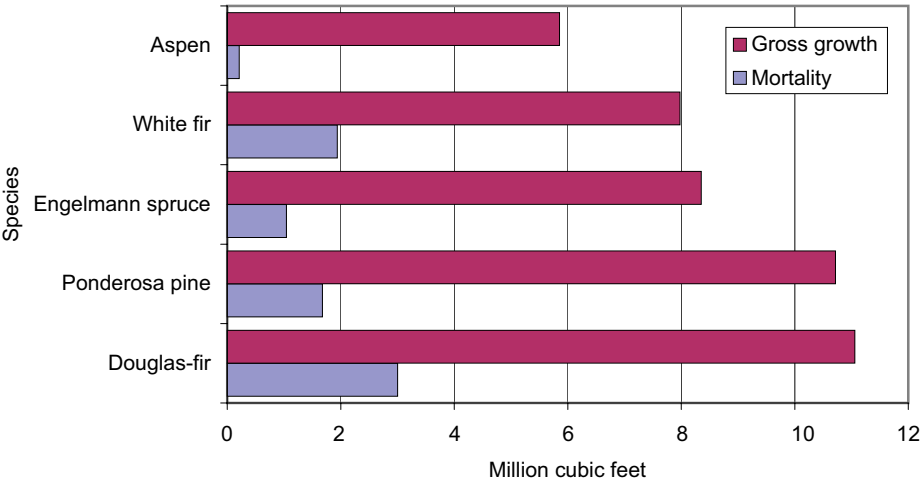


Figure 10—Gross annual growth of live trees 5 inches diameter and greater compared to mortality on all forest land, Santa Fe National Forest.

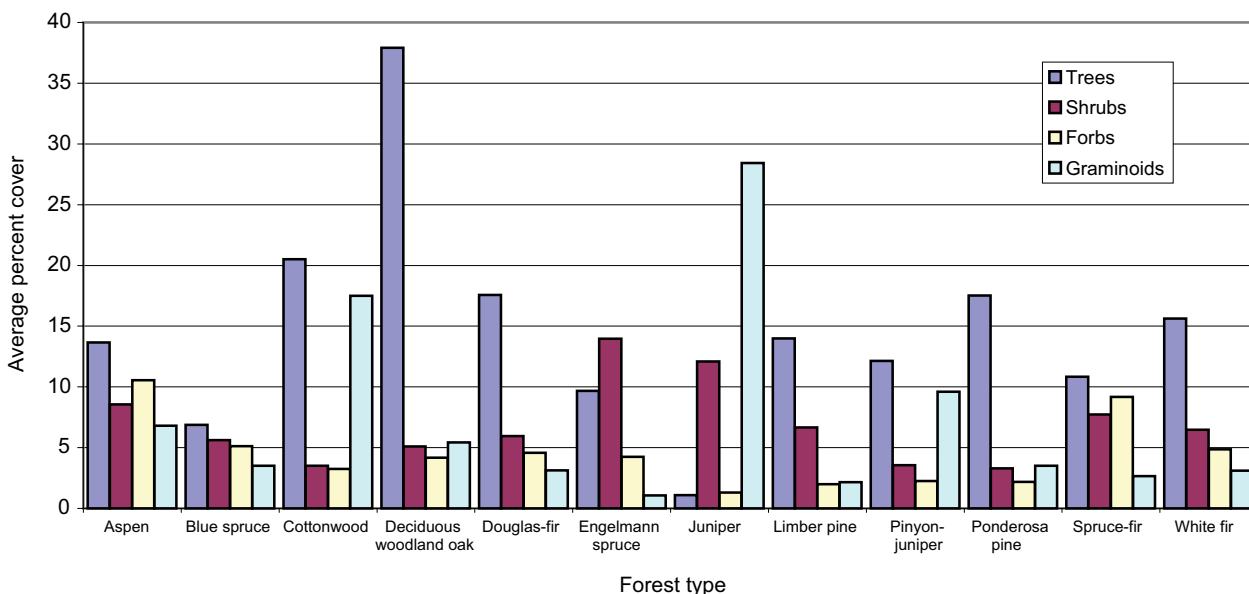


Figure 11—Average percent cover of trees (seedlings/saplings), shrubs, forbs, and graminoids on forest land by forest type, Santa Fe National Forest.

Nonreserved timberland: highlights of our inventory

Tree and stand size—Over 47 percent of forest land in the Santa Fe 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 Santa Fe (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 Santa Fe. Growing-stock trees are live timber species meeting

specific standards of quality and vigor. Of all growing-stock trees on nonreserved timberland on the Santa Fe, 22 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 Santa Fe. The total net cubic-foot volume of growing stock on nonreserved timberland is about 1.6 billion cubic feet. Ponderosa pine and Douglas-fir each account for 31 percent of this volume. The total wood biomass is estimated at 29 million tons,

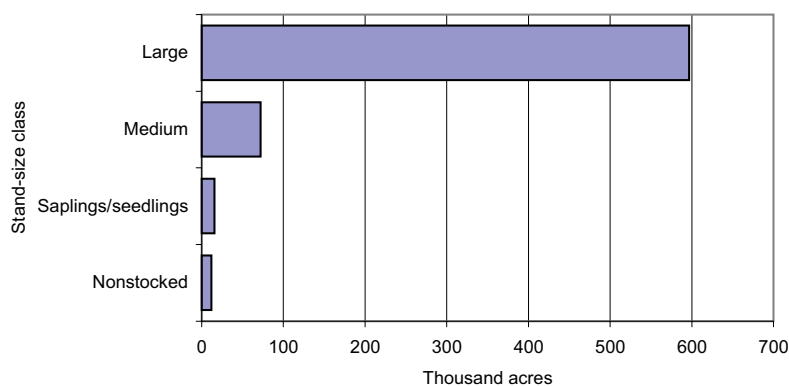


Figure 12—Area of nonreserved timberland by stand-size class, Santa Fe National Forest.

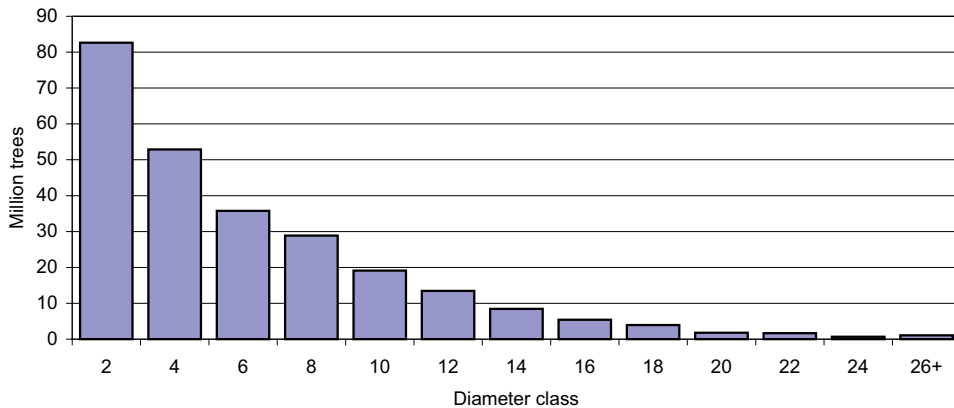


Figure 13—Number of growing-stock trees on nonreserved timberland by 2-inch diameter class, Santa Fe National Forest.

Table 4—Net volume, biomass, and basal area of growing-stock trees 5 inches diameter and greater by species on nonreserved timberland, Santa Fe National Forest

Species	Volume (million cubic feet)	Biomass (million tons)	Basal area (million square feet)
Douglas-fir	493.9	9.4	22.2
Ponderosa pine	481.3	9.4	24.6
White fir	233.1	4.2	12.3
Aspen	134.9	2.3	5.9
Engelmann spruce	109.4	1.7	4.7
Limber pine	58.5	1.0	3.3
Blue spruce	35.0	0.5	1.3
Corkbark fir	23.6	0.4	1.1
Narrowleaf cottonwood	4.2	†	0.2
Total*	1,573.9	29.0	75.6

† less than 100,000 tons

* numbers may not add to total due to rounding

with ponderosa pine and Douglas-fir each making up 32 percent of this amount. Total basal area for growing-stock trees on nonreserved timberland is estimated at nearly 76 million square feet, with ponderosa pine comprising 33 percent and Douglas-fir 29 percent of this total.

The total net sawtimber volume on nonreserved timberland is estimated at 5.8 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.

Ponderosa pine, 34 percent, and Douglas-fir, 32 percent, account for the majority of this volume.

Growth and mortality—Gross annual growth of growing-stock trees on nonreserved timberland on the Santa Fe is estimated to be 32.8 million cubic feet, while mortality is estimated at 4.2 million cubic feet. This calculates to a net annual growth of 28.7 million cubic feet. The majority of the mortality volume was attributed to four species, with

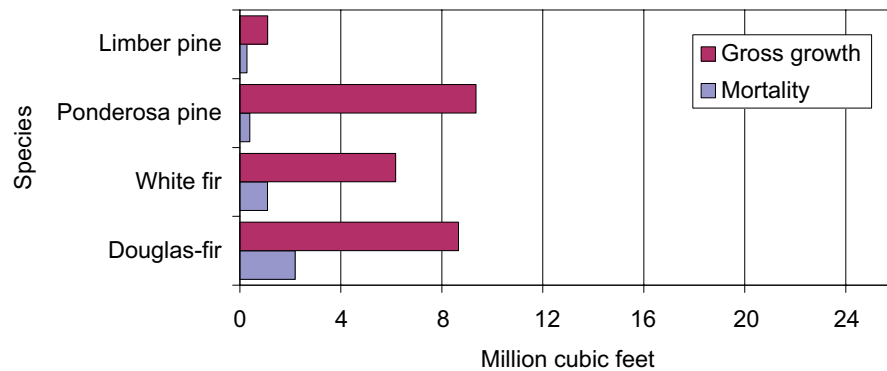


Figure 14—Gross annual growth of growing-stock trees 5 inches diameter and greater compared to mortality on nonreserved timberland, Santa Fe National Forest.

Douglas-fir accounting for over half of this total at 53 percent. Gross annual growth is compared to mortality in figure 14 for the four species with the largest mortality. Mortality for nonreserved timberland on the Santa Fe is about 13 percent of gross annual growth with Douglas-fir and limber pine have the largest mortality-to-growth ratio.

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 255 field plots on the Santa Fe National

Forest, of which two were determined to be inaccessible. A total of 231 field plots sampled only forest conditions, 10 sampled both forest and nonforest conditions, and 12 sampled only nonforest conditions. A total of 261 forest conditions (stands) were sampled on 241 plots that contain 236.7 forest and 16.3 nonforest/water 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 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), Santa Fe National Forest.

Land class	Attribute	Estimate	Percent standard error
Total forest land (acres)	Area	1,463,523	± 1.7
Total forest land (all trees cubic feet)	Volume	2,896,474,236	± 6.0
	Growth	44,766,900	± 7.8
	Mortality	9,787,594	± 24.1
Nonreserved timberland (acres)	Area	696,142	± 5.5
Nonreserved timberland (growing-stock trees cubic feet)	Volume	1,573,918,827	± 9.3
	Growth	28,675,998	± 9.1
	Mortality	4,155,778	± 35.9



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FAX: 801-625-5723
World Wide Web: <http://www.fs.fed.us/rm/ogden>

Santa Fe National Forest
Forest Supervisor
1474 Rodeo Rd.
Santa Fe, NM 87502-7115
Phone: 505-438-7840
FAX: 505-438-7834

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. Select FIADB for data.

http://www.fs.fed.us/rm/ogden/data_retrieval.html



The Rocky Mountain Research Station develops scientific information and technology to improve management, protection, and use of the forests and rangelands. Research is designed to meet the needs of National Forest managers, Federal and State agencies, public and private organizations, academic institutions, industry, and individuals.

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.

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