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Forest Resources of the Prescott 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 Prescott National Forest 1996 inventory, including tree population estimates and summaries of commonly requested variables.

The information presented in this report is based solely on the IWFIA inventory sample (USDA 1996a). This 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 O'Brien (2002), USDA (2002a), 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 Prescott National Forest, used separately or in combination with IWFIA data, may produce varying results.

Since the results tabulated in this report reflect data collected by field crews chiefly during the year 1996, changes in forest characteristics that have taken place since that time are not addressed. Any trends or disturbances (such as, fire) that have occurred after 1996 will be discussed in future reports on the Prescott National Forest.

Description of the Forest

The Prescott National Forest administers 1,238,803 acres (USDA 1996b), of which 59 percent is classified as forest land and 41 percent nonforest or water. This report describes the characteristics of the forest land sampled on the Prescott National Forest. *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 predominate tree species present, forest land can be further subdivided into two land categories: timberland and woodland (fig. 1). *Timberland* is forest land where the predominance of tree species tallied have been traditionally used in the wood products industry, such as ponderosa pine and Douglas-fir. *Woodland* primarily includes tree species that typically do not conform to breast height diameter measurement or have not been traditionally used for industrial wood products, such as pinyon pine, junipers, and oaks. Focusing on forested land only, 91 percent is woodland and 9 percent is timberland.

Eight percent of the total forested area administered by the Prescott National Forest is reserved land, meaning that

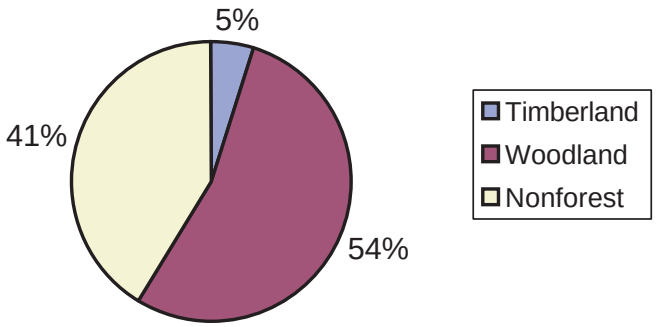

Figure 1—Percent of total area by land category, Prescott National Forest.

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. A subsequent section addresses nonreserved timberland only and includes estimates for timber species sampled on the Prescott 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 Prescott National Forest by forest type. Pinyon-juniper and juniper types clearly dominate the forest type coverage. While the pinyon-juniper forest type, at 49 percent, covers the largest extent of forest land, the combined total of pinyon-juniper and pure juniper equals 82 percent of all forest land. The remaining 18 percent is comprised of a variety of timber and woodland types including ponderosa pine, evergreen and deciduous woodland oaks, mesquite, and Douglas-fir.

A field plot may sample more than one condition. 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 (for further explanation of conditions, see "About the mapped-plot design" page 11). Table 1 presents the number of conditions and the condition proportions sampled on the Prescott National Forest by forest type and land category.

Table 1—Number of conditions and condition proportions on forest land by forest type and land category, Prescott National Forest, 1996.

Forest type	Number of conditions[a]	Condition proportions[b]
Timberland		
Ponderosa pine	8	7.4
Douglas-fir	2	2.0
Total Timberland	10	9.4
Woodland		
Pinyon-juniper	60	55.6
Juniper	41	37.2
Evergreen woodland oak	10	6.8
Deciduous woodland oak	2	1.4
Mesquite	2	2.0
Total Woodland	115	103.0
Grand Total	125	112.5

[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 composition of tree species. Figure 3 shows total number of live trees for the most common tree species sampled for three broad diameter classes. The largest proportion of trees on the forest are in the smallest diameter class. Utah juniper leads in each of the three diameter

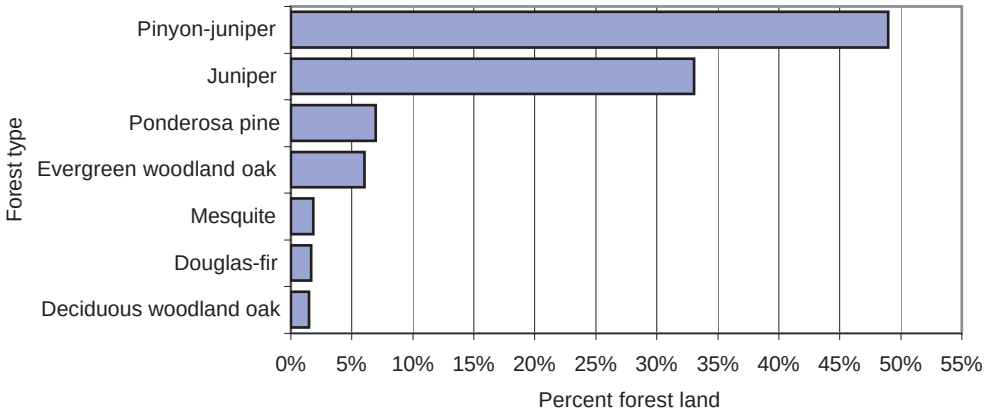

Figure 2—Percent of total forest land area by forest type, Prescott National Forest.

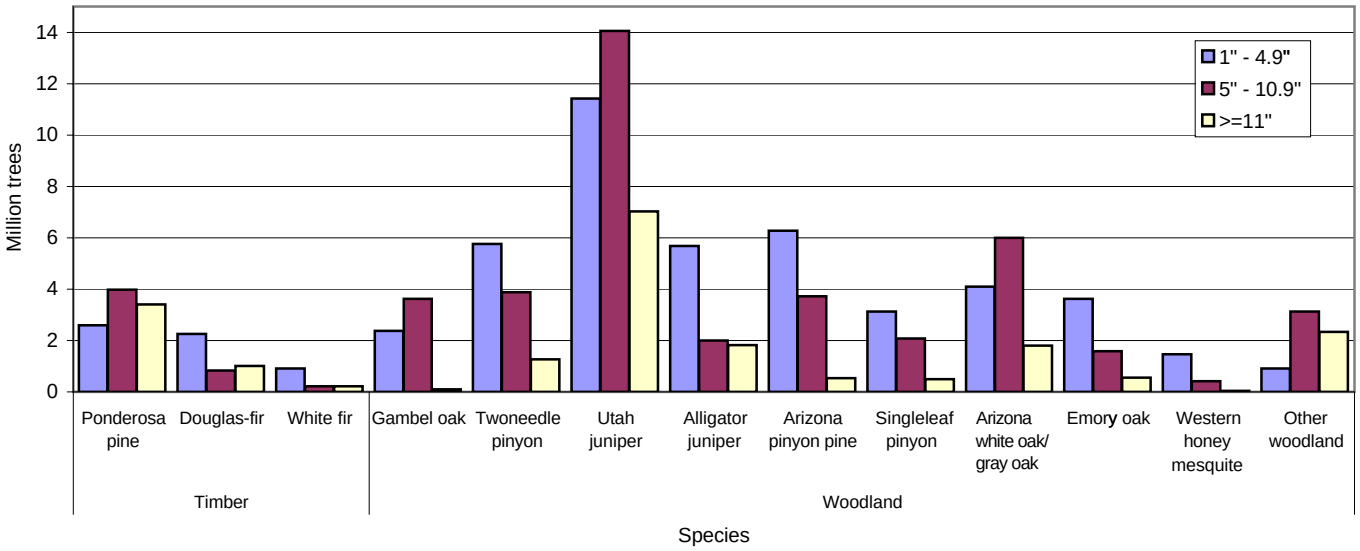

Figure 3—Number of live trees 1 inch diameter and greater on forest land by species and diameter-size class, Prescott National Forest.

classes, accounting for 28 percent of all trees tallied on the forest. A complete list of tree species sampled during this inventory, including remaining woodland species of the "Other woodland species" category in figure 3, is found in table 2. Less common species may not be tallied with the 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 wildlife, function as nutrient sinks, and protect the soil from erosion. Approximately 4 million

standing dead trees (snags) are 1 inch diameter and greater on Prescott forest land, averaging 5.4 snags per acre. Different size snags offer variety in habitat for wildlife. Figure 4 shows the number of standing dead trees by forest type for three diameter size classes. Of the total numbers of snags, 28 percent are between 1 inch and 4.9 inches diameter, with virtually all of these occurring within the deciduous woodland oak forest type. Forty percent are between 5 and 10.9 inches diameter. Snags 11 inches diameter or larger make up 32 percent of the total, averaging 1.7 large snags per acre. Forty-one percent of all large snags are found in pinyon-juniper, with fewer snags recorded in other forest types.

The amount of down dead material can contribute significantly to forest fuel loads and fire potential. Approximately 276,816 tons of down dead trees are on the Forest, averaging .38 tons per acre. This estimate includes the merchantable bole and bark of trees 5 inches diameter and greater. Utah juniper comprises 33 percent of this estimate, with another 25 percent coming from ponderosa pine.

Tree and stand size—The size distribution of trees is an indicator of diversity across a landscape. Figure 5 displays the tree size distribution by diameter class on the Prescott National Forest. Forty–three percent of all live trees are from 1 to 4.9 inches diameter. Thirty-nine percent of all live trees are from 5 to 10.9 inches diameter, and 18 percent are 11 inches diameter and greater.

Stand-size class is a categorization of forest land based on the predominant diameter-size of live trees that contribute to the plurality of stocking in a stand. The large di-

Table 2—Net volume, basal area , and biomass on forest land by species, Prescott National Forest, 1996.

Species	Volume (million cubic-feet)	Basal area (million square feet)	Biomass (million tons)
Utah juniper	112.4	15.3	1.4
Ponderosa pine	102.2	5.2	2.0
Alligator juniper	41.2	4.3	0.5
Oneseed juniper	37.0	5.0	0.5
Douglas-fir	34.1	1.5	0.6
Two-needle pinyon	33.9	2.6	0.4
Arizona white oak/gray oak	31.9	4.1	1.0
Arizona pinyon pine*	17.0	1.6	0.2
Emory oak	14.6	1.3	0.4
Singleleaf pinyon*	12.4	1.1	0.2
Gambel oak	10.0	1.0	0.3
White fir	6.3	0.3	0.1
Western honey mesquite	0.6	0.2	‡
Rocky Mountain Maple	0.2	†	‡
New Mexico locust	0.1	†	‡
Evergreen woodland oak	+	†	‡
Total (all tree species)**	453.7	43.5	7.6

+ less than 100,000 cubic–feet
† less than 100,000 square feet
‡ less than 100,000 tons
* In the FIA inventories of Arizona and New Mexico, single-needle varieties of pinyon pine were not consistently identified. They could be listed as either Singleleaf or Arizona pinyon.
** numbers do not add to total due to rounding

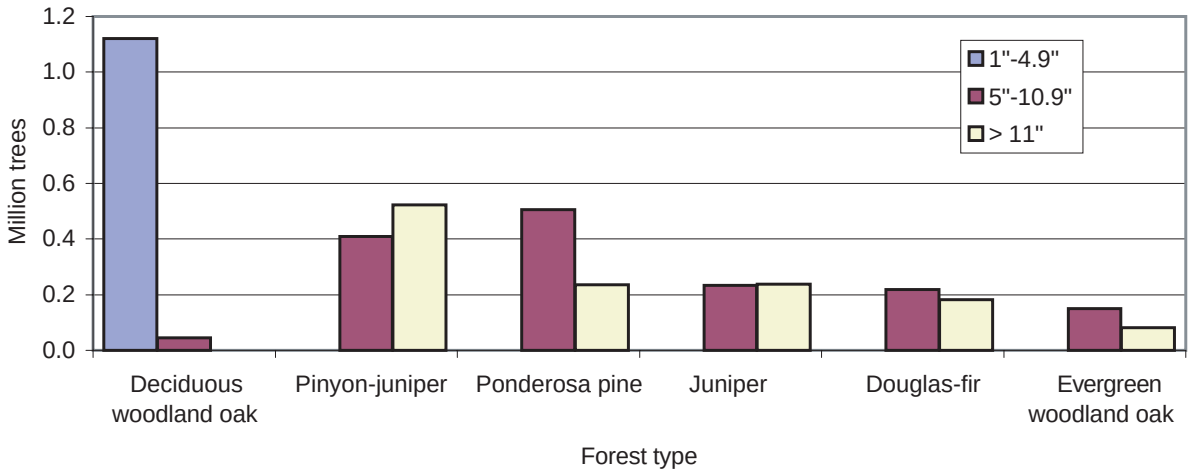

Figure 4—Number of standing dead trees 1 inch diameter and greater on forest land by forest type and diameter-size class, Prescott National Forest.

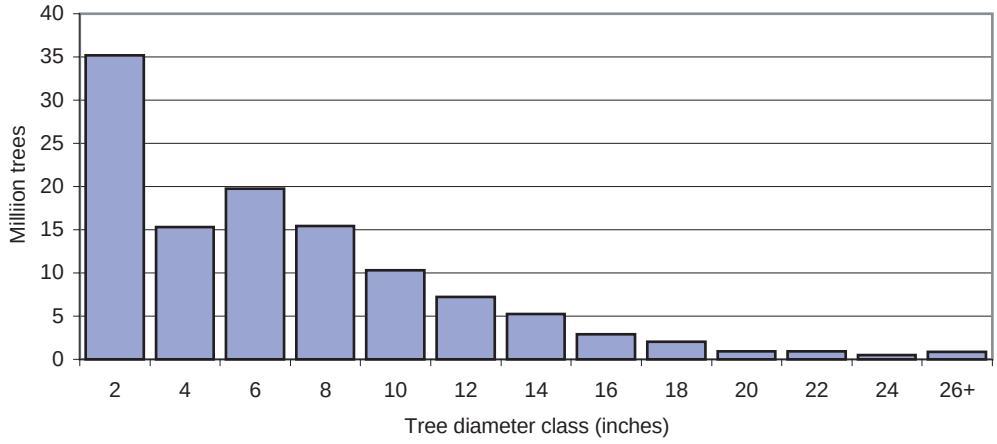

Figure 5—Number of live trees on forest land by 2-inch diameter class, Prescott National Forest.

ameter class includes softwoods 9 inches diameter and greater, and hardwoods 11 inches diameter and greater; the medium diameter class includes softwoods 5.0 to 8.9 inches diameter, and hardwoods 5 to 10.9 inches diameter; and the small diameter class (saplings and seedlings) includes all trees under 5 inches diameter. 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 a breakdown of forest land by stand-size class. Approximately 72 percent of the stands have a plurality of stocking from large trees and 13 percent are nonstocked as a result of recent disturbance, such as burning or cutting.

Wood volume, basal area of live trees, and biomass—Estimates of volume, basal area, and biomass describe the amount of wood fiber in the forest. Each estimate summarizes different parts of a tree and therefore has different applications. For example, volume relates to wood products, basal area to tree or stand density, and biomass to total tree or stand production. In table 2, volume represents the amount of wood fiber in the merchantable bole of a tree. Basal area estimates include the cross-sectional area of a tree stem (bole) at the point where diameter is measured. In this summary, biomass represents the amount of wood fiber in terms of oven-dry weight including the tree boles, bark, and branches (not foliage). Table 2 shows a breakdown by all sampled species of net volume, basal

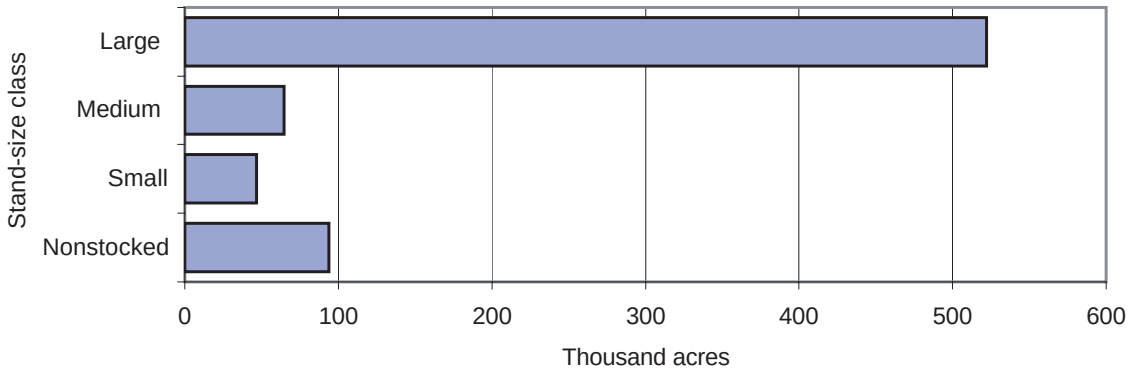

Figure 6—Area of forest land by stand-size class, Prescott National Forest. Large trees include softwoods 9 inches and greater and hardwoods 10 inches and greater; medium trees include softwoods 5 to 8.9 inches and hardwoods 5 to 10.9 inches; saplings and seedlings include trees less than 5 inches.

area, and biomass for live trees 5 inches diameter and greater on the Prescott National Forest. Utah juniper leads all species in overall volume (25 percent) and basal area (35 percent), however ponderosa pine has more biomass than Utah juniper (26 and 18 percent, respectively).

Figure 7 shows the distribution of net volume of wood in trees by diameter class on Prescott forest land. While the number of trees decreases with each larger diameter class (see fig. 5), volume maximizes at diameter classes from 12 to 14 inches before generally tapering in the largest size classes.

Another way to look at wood volume is by forest type, for which per acre estimates can be computed along with basal area and biomass (table 3). These numbers include the many different species that can occur together within each forest type. The highest volumes per acre on the Prescott National Forest are recorded in Douglas-fir and ponderosa pine forest types, followed by evergreen and deciduous oak woodlands. These forest types also contain the highest basal area and biomass per acre, as these attributes are strongly correlated with volume.

It should be noted that many of the forest types listed in table 3 may not be representative due to small sample

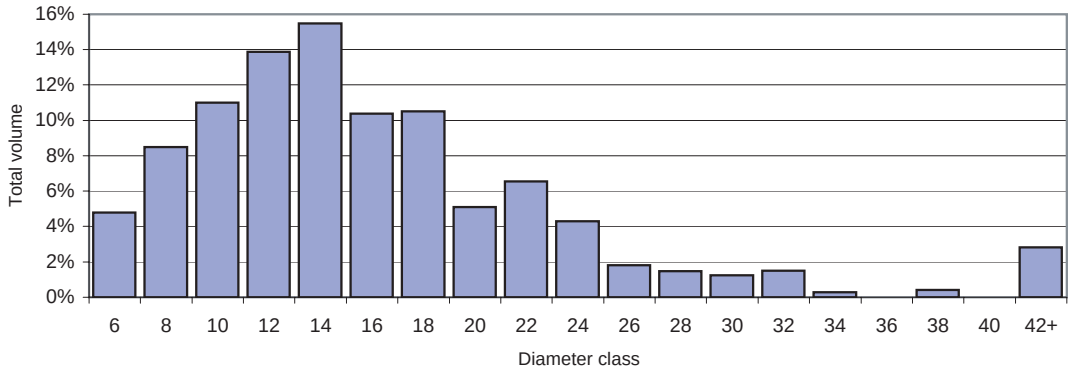

Figure 7—Percent of total net cubic-foot volume of live trees by diameter class, Prescott National Forest.

Table 3—Net volume, basal area, and biomass per acre on forest land by forest type, Prescott National Forest, 1996.

Forest type	Volume (cubic-feet per acre)	Basal area (square feet per acre)	Biomass (tons per acre)
Douglas-fir	4,206	202	79.5
Ponderosa pine	2,109	135	43.0
Evergreen woodland oak	894	87	22.5
Deciduous woodland oak	802	80	21.8
Pinyon-juniper	447	49	5.6
Juniper	371	50	5.0
Mesquite	22	5	.8
All forest types (combined)	624	60	10.4

sizes (see table 1). Only pinyon–juniper and juniper forest types have large enough samples for high quality per acre estimations on the Prescott National Forest.

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 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 (Long and Daniel 1990). Based on FIA sample data, 23 percent of all forest stands in the Prescott 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 predominate 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. Contrasting stand structures provide diversity across landscapes. 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 pine and mixed conifer forest types. On the Prescott National Forest, the pine category is made up of ponderosa pine and the mixed conifer category includes Douglas-fir. 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 Prescott National Forest is represented by both single-storied and multistoried stands, but the distribution within single-storied stands occurs mainly in the 5-11.9 inch diameter class.

Growth and Mortality—Another measure of forest vigor is net annual growth. Net annual growth is the difference between gross annual growth and losses due to 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 1996 approximately 500,000 cubic feet of wood 5 inches diameter and greater died on the Prescott National Forest. Ponderosa pine generated the highest volume of mortality at just over 230,000 cubic feet. However, gray oak and Arizona pinyon pine had higher percentages of mortality at 18 and 17 percent, respectively. Ponderosa pine exhibited a low mortality percentage, 11 percent, because of its high gross growth volume.

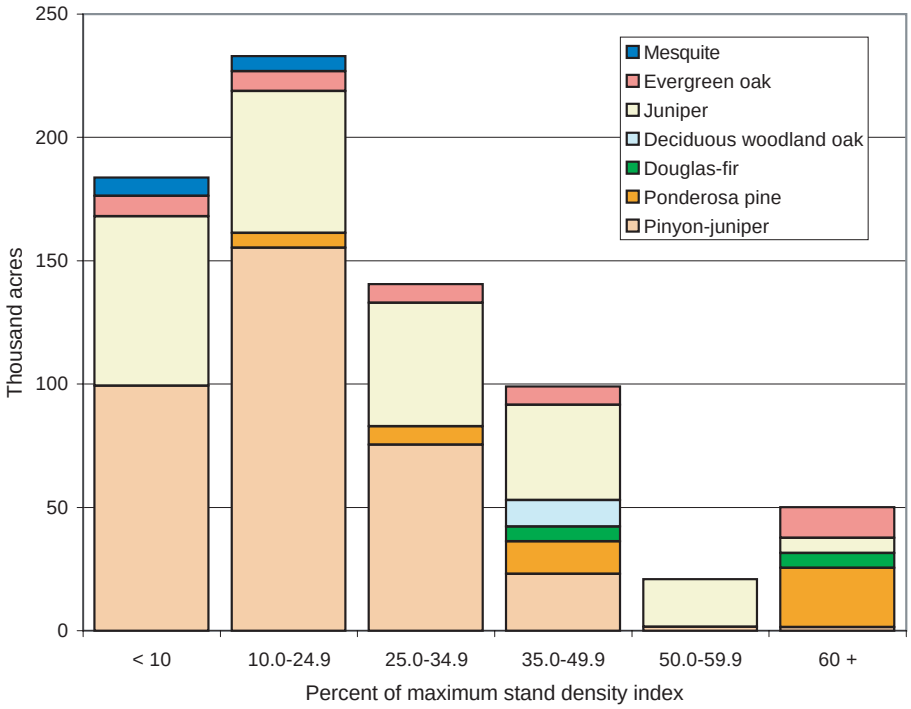

Figure 8—Area of forest land by forest type and percent stand density index, Prescott National Forest.

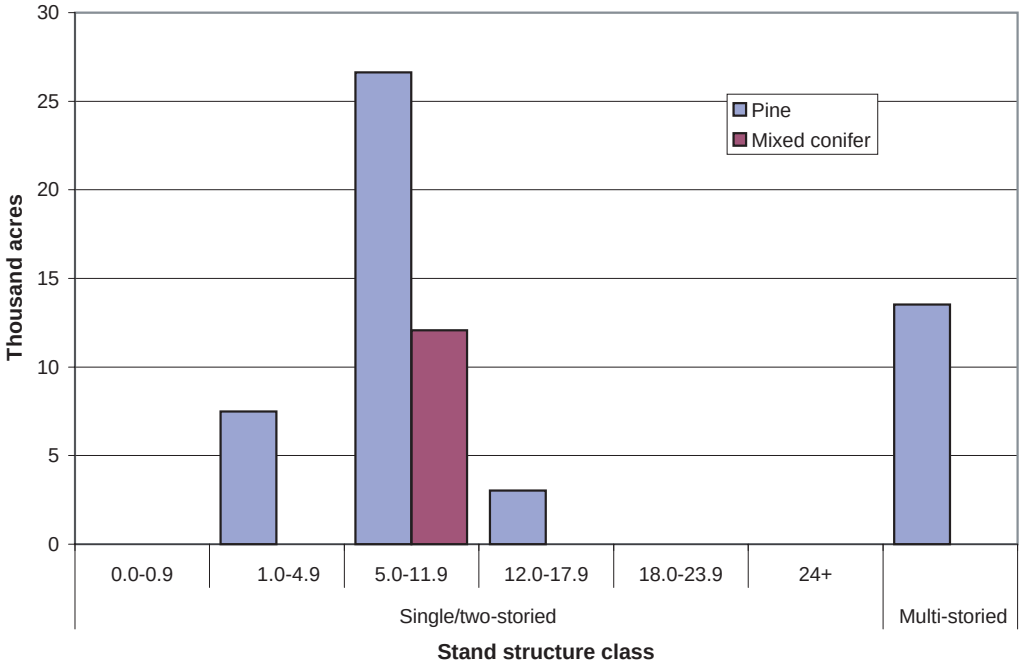

Figure 9—Area of forest land by stand-structure class, diameter class, and timber softwood forest type groups, Prescott National Forest.

Gross annual growth of all live trees 5 inches diameter and greater on all Prescott forest land is estimated at 6.3 million cubic feet. By deducting the estimated mortality from the gross growth we calculated a net annual growth of 5.8 million cubic feet. Total mortality is about 8 percent of gross annual growth. In figure 10 gross annual growth is compared to mortality for the eight highest growth species. Growth in all species far outstrips mortality on the Prescott National Forest.

Field crews also estimate the causes of mortality, when possible. Sixty-four percent of the mortality on the Prescott National Forest was caused by disease and 35 percent by fire. The remaining 1 percent was attributed to undetermined causes.

Understory vegetation—Understory vegetation provides forage and cover for wildlife, contributes to forest fuel load, adds to total forest biomass, and can be an indication of the successional stage of the forest community. On

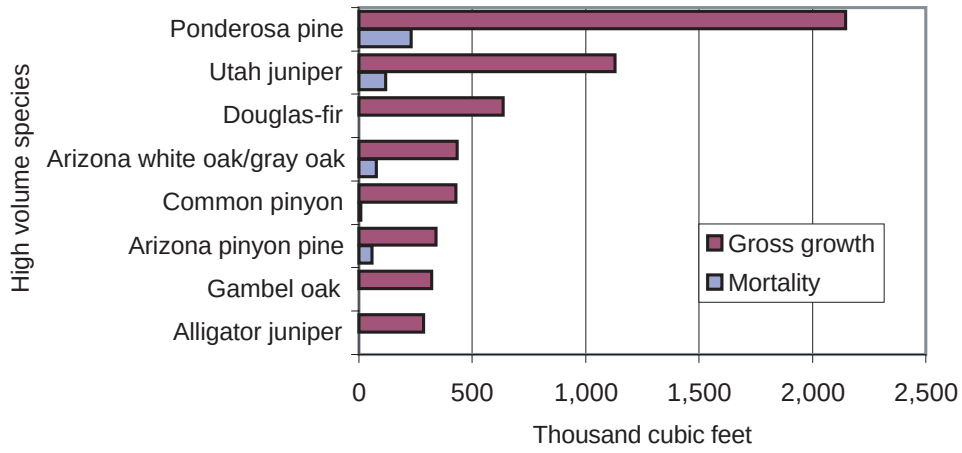

Figure 10—Gross annual growth of live trees 5 inches diameter and greater compared to mortality on all forest land, Prescott National Forest.

each plot field crews visually estimated crown canopy coverage for four plant groups: tree seedlings and saplings, shrubs, forbs, and graminoids (see USDA 1996a for details). Figure 11 shows the average percent cover of these plant groups on forest land by forest type.

Nonreserved timberland: highlights of our inventory

Tree and stand size—Eight percent of forest land in the Prescott National Forest is nonreserved timberland. All 62,000 acres of nonreserved timberland (i.e., excluding woodland stands) falls in the 9.0 inches diameter and greater stand size class

Figure 12 shows the distribution of diameter-size classes for growing-stock trees on nonreserved timberland on the Prescott National Forest. *Growing-stock* trees are live timber species meeting specific standards of quality and vigor. Of all growing-stock trees on nonreserved timberland, 38 percent are 9 inches diameter or greater.

Wood volume, basal area, and biomass of growing-stock trees—Table 4 displays net cubic-foot volume, square foot basal area, and tons of wood biomass for

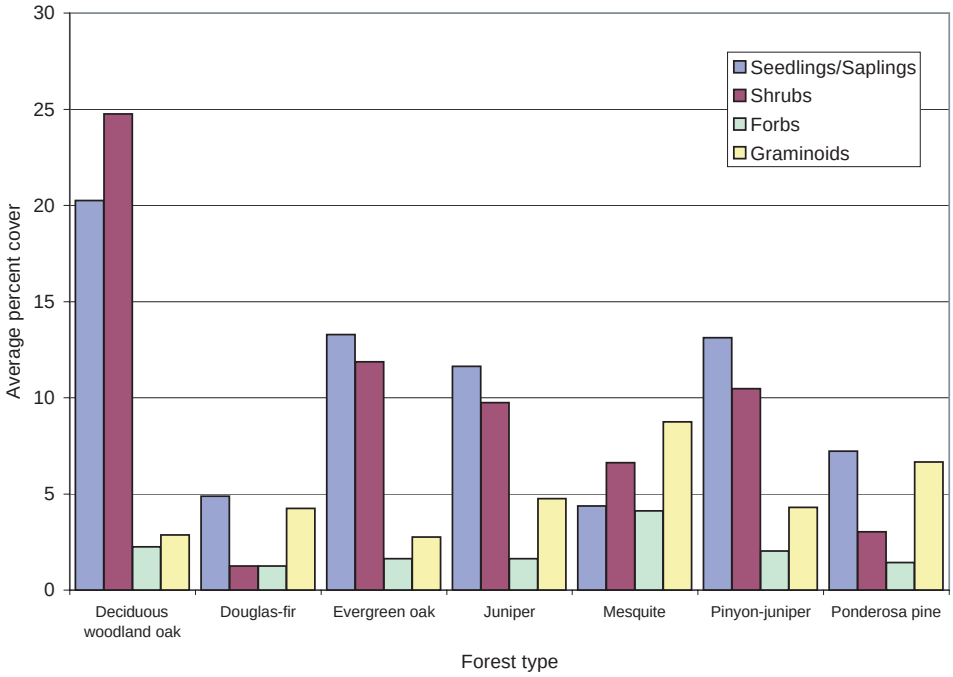

Figure 11—Average percent cover of seedlings and saplings, shrubs, forbs, and graminoids on forest land by forest type, Prescott National Forest.

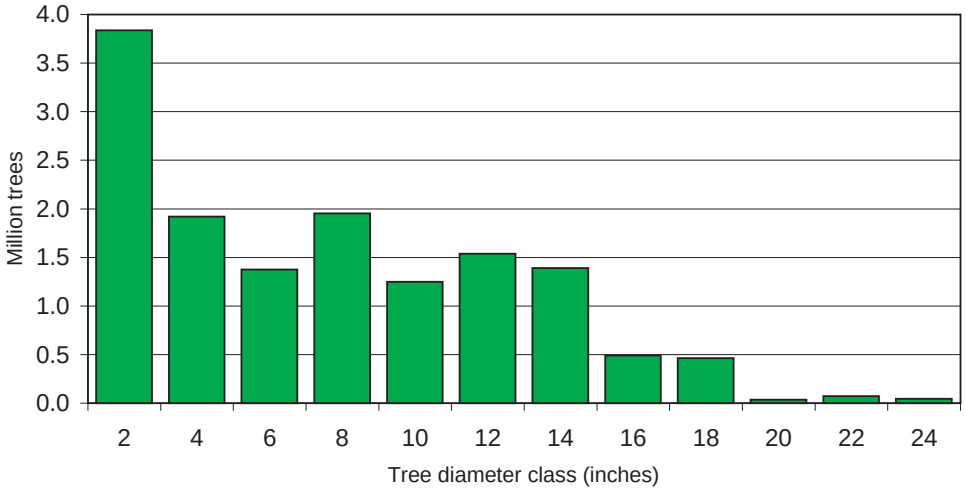

Figure 12—Number of growing-stock trees on nonreserved timberland by 2-inch diameter class, Prescott National Forest.

Table 4–Net volume, basal area, and biomass of growing-stock trees 5 inches diameter and greater by species on nonreserved timberland, Prescott National Forest, 1996.

Species	Volume (Million cubic feet)	Basal area (Million square feet)	Biomass (Million tons)
Ponderosa pine	86	4.3	1.6
Douglas-fir	34	1.5	.6
White fir	6	.3	.1
Total*	127	6.2	2.4

* numbers may not add to total due to rounding

growing-stock trees 5 inches diameter and greater by species on nonreserved timberland for the Prescott National Forest. The total net cubic-foot volume of growing stock on nonreserved timberland is about 126 million cubic feet. Ponderosa pine accounts for 68 percent of this volume. Total basal area for growing-stock trees on nonreserved timberland is estimated at 6.2 million square feet, with ponderosa pine comprising 70 percent of this total. The total wood biomass is estimated at 2.4 million tons, with ponderosa pine making up over 68 percent of this amount.

The total net sawtimber volume on nonreserved timberland is estimated at 468 million 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 accounts for the majority, 67 percent, of this volume.

Growth and Mortality—Gross annual growth of growing stock on nonreserved timberland on the Prescott National Forest is estimated to be 2.4 million cubic feet, while mortality is estimated at 231 thousand cubic feet. This calculates to a net annual growth of 2.2 million cubic feet. Gross annual growth is compared to mortality for the three species in figure 13. All of the mortality volume on the Prescott National Forest was attributed to ponderosa pine. Mortality for nonreserved timberland is about 9 percent of gross annual growth.

The inventory methods

About the two-phase design—FIA inventories provide a statistical-based sample of forest resources across all ownerships that can be used for planning and analyses at local,

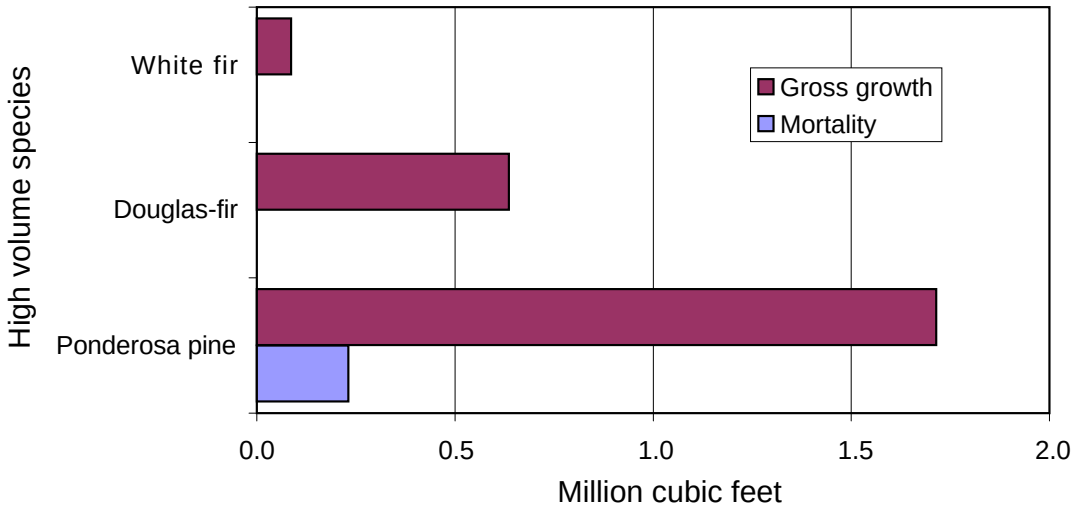

Figure 13—Gross annual growth of growing-stock trees compared to mortality on nonreserved timberland, Prescott National Forest.

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 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.

About the mapped-plot design—The mapped-plot design was adopted by FIA nationwide by 1995. The predetermined subplot layout uses boundary delineation 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.

In summary, there were 193 field plots on the Prescott National Forest, of which two were determined to be inaccessible. Of the 191 plots that were field sampled, 105 sampled only forest conditions, 10 sampled both forest and nonforest conditions, and 76 sampled only nonforest conditions.

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 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 of total forest land, and percent errors for estimates of net volume, net annual growth, and annual mortality for all live trees on total forest land, and growing-stock trees (5 inches diameter and greater) on nonreserved timberland, Prescott National Forest.

Land class	Attribute	Estimate	Percent standard error
Total forest land (acres)	Area	727,232	±5.8
Total forest land	Volume	453,702,049	±12.6
(all trees cubic feet)	Growth	5,856,769	±15.7
	Mortality	505,771	±58.1
Nonreserved timberland	Volume	126,635,900	±35.6
(growing-stock cubic feet)	Growth	2,205,445	±36.3
	Mortality	231,055	±100.0

Documentation

Long, James N.; Daniel, Theodore W. 1990. Assessment of growing-stock in uneven-aged stands. Western Journal of Applied Forestry 5(3):93-96.

O'Brien, Renee A. 2002. Arizona's Forest Resources, 1999. Resour. Bull. RMRS-RB-2. Ogden, UT: U. S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 116 p.

Reineke, L.H. 1933. Perfecting a stand density index for even-aged forests. J. Agric. Res. 46:627-638.

U.S. Department of Agriculture, Forest Service. 1991. RMSTAND User's Guide, Chapter 60, p. 106. Unpublished user's guide on file at: U.S. Department of Agriculture, Forest Service, Southwestern Region, Albuquerque, NM.

U.S. Department of Agriculture, Forest Service. 1996a. Arizona/New Mexico Region 3 forest survey field procedures, 1996. Ogden, UT: USDA Forest Service, Intermountain Research Station.

U.S. Department of Agriculture, Forest Service. 1996b. Land Areas of the National Forest System. FS-383. As of September 1996.

U.S. Department of Agriculture, Forest Service. 2002a. Reference documents. [Online]. Available: http://www.fs.fed.us/rm/ogden/state_reports/arizona/az_nfs.html (also available on file at: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT).

U.S. Department of Agriculture, Forest Service. 2002b. Region-3 Guide For Custom IW-FIA Table Set, 2002. Unpublished report on file at: U.S. Department of Agriculture, Forest Service, Southwestern Region, Albuquerque, NM.

For further information

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World Wide Web: http://www.fs.fed.us/r3/prescott/

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://ncrs2.fs.fed.us/4801/fiadb/index.htm

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.