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Arkansas' Forests, 2010

James F. Rosson, Jr. and
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Front cover: top left, the Morris Pine, a 300+ year-old loblolly pine growing on the Levi Wilcoxon Demonstration Forest in Ashley County, AR. (photo by Don C. Bragg, Southern Research Station); top right, measuring a shortleaf pine on an FIA sample plot, Polk County, AR. (photo by Darren Spinks, Arkansas Forestry Commission); bottom, the Buffalo River in Newton County, AR. (photo by James M. Guldin, Southern Research Station). Back cover: top left, two years after a light burn in the Ouachita Mountains, AR. (photo by James M. Guldin, Southern Research Station); top right, the Morris Pine, a 300+ year-old loblolly pine growing on the Levi Wilcoxon Demonstration Forest in Ashley County, AR. (photo by Don C. Bragg, Southern Research Station); bottom, harsh growing conditions on a south-facing slope in the Ouachita Mountains, Polk County, AR. (photo by Darren Spinks, Arkansas Forestry Commission)

Harsh growing conditions on a south-facing slope in the Ouachita Mountains, Polk County, AR. (photo by Darren Spinks, Arkansas Forestry Commission)

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Cedar Falls at the end of the Cedar Falls Trail at Petit Jean State Park near Morrilton, AR. (photo courtesy of wikimedia.org)

FOREWORD

The U.S. Department of Agriculture Forest Service, Southern Research Station's Forest Inventory and Analysis (FIA) research work unit and cooperating State forestry agencies conduct annual forest inventories of resources in the 13 Southern States (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia), the Commonwealth of Puerto Rico, and the U.S. Virgin Islands. In order to provide more frequent and nationally consistent information on America's forest resources, all research stations and their respective FIA work units conduct annual surveys with a common sample design. These surveys are mandated by law through the Agricultural Research Extension and Education Reform Act of 1998 (Farm Bill).

The primary objective in conducting these inventories is to gather the resource information needed to formulate sound forest policies, provide information for economic development, develop forest programs, and provide a scientific basis to monitor forest ecosystems. These data are used to provide an overview of forest resources including, but not limited to, forest area, forest ownership, forest type, stand structure, timber volume, growth, removals, mortality, and management activity. In addition, less intensive assessments are done that help address issues of ecosystem health; such assessments include information about ozone-induced injury, down woody material, and tree crown condition. This information is applicable at the multi-State, individual State, and survey unit level; it provides the necessary background for initiation of more intensive studies of critical situations but is not designed to reflect resource conditions at very small scales.

More detailed information about sampling methodologies used in the annual FIA inventories can be found in "The Enhanced Forest Inventory and Analysis Program—National Sampling Design and Estimation Procedures" (Bechtold and Patterson 2005).

Data tables included in FIA reports are designed to provide an array of forest resource estimates, but additional tables can be obtained at: http://fia.fs.fed.us/tools-data/other/default.asp. Additional information about the FIA program can be obtained at: http://fia.fs.fed.us/.

Additional information about any aspect of Southern Research Station FIA surveys may be obtained from:

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The FIA program would also like to thank the Arkansas Forestry Commission for continued assistance, cooperation, and partnership in fulfilling the FIA mission goals. Also, we would like to acknowledge a special thanks to Darren Spinks of the Arkansas Forestry Commission for continued excellent supervision of Arkansas field crews and in keeping field logistics on track.

Loblolly cones. (photo by Erich G. Vallery, USDA Forest Service, Bugwood.org)

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Road cut on Highway 65 south of Marshall revealing the characteristic uplifted dolomitic geology of the Ozark Mountains, Searcy County, AR. (photo by James M. Guldin, Southern Research Station)

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The Buffalo River near the Hasty access, Newton County, AR. (photo by James M. Guldin, Southern Research Station)

HIGHLIGHTS

Important findings of the ninth forest survey of Arkansas are presented below. Comparisons and trends, unless otherwise noted, are based on estimates between the 2005 and 2010 surveys of Arkansas.

• There was a 442,900-acre increase in forest land. This brings the current estimate to 18.7 million acres of forest land across the State.

• Fifty-six percent of Arkansas is in forest land.

• Sixty percent of forest land was in nonindustrial private forest ownership, 20 percent was in forest industry, 13 percent in national forest, and 6 percent was in other public ownership.

• The predominant forest-type group was oak-hickory (41 percent of all forest land) followed by loblolly-shortleaf pine (29 percent).

• Live-tree volume for the State was 29.2 billion cubic feet, up 6 percent since 2005. Thirty-eight percent was in softwoods, 62 percent was in hardwoods. Loblolly and shortleaf pine were the most dominant trees across the State and together accounted for 35 percent of all live-tree volume.

• Softwood volume was 11.2 billion cubic feet, an increase of 750.8 million cubic feet (7 percent).

• Hardwood volume was 18.0 billion cubic feet, an increase of 903.7 million cubic feet (5 percent).

• Sawtimber volume was 97.2 billion board feet, up 10 percent since 2005. Forty-seven percent was in softwoods, 53 percent was in hardwoods.

• Softwood sawtimber volume was 45.9 billion board feet, an increase of 3.7 billion board feet (9 percent).

• Hardwood sawtimber volume was 51.4 billion board feet, an increase of 4.9 billion board feet (11 percent).

• Live-tree growth on forest land was 1.2 billion cubic feet per year. Sixty percent of this was in softwoods, 40 percent was in hardwoods. Loblolly pine led the State in growth with 583.1 million cubic feet per year.

• Live-tree removals were 858.6 million cubic feet per year, with 64 percent in softwoods and 36 percent in hardwoods. Loblolly pine led the State in removals with 447.3 million cubic feet per year.

• Live-tree mortality was 227.3 million cubic feet per year. Twenty-five percent was in softwoods, 75 percent in hardwoods. Loblolly and shortleaf pines led in mortality with 29.9 and 23.9 million cubic feet per year, respectively.

• There were 3.3 million acres of plantations in Arkansas, 17 percent of all forest land. This was a 323,200-acre increase since 2005.

• There were 2.9 billion cubic feet of softwood live-tree volume on plantations, a 226.7 million cubic foot increase. Plantation softwood volume was 26 percent of all live-tree softwood volume in the State.

• Softwood growth, on plantations, was 346.2 million cubic feet per year, 46 percent of all softwood live-tree growth in the State.

• The basal area of forest land stands averaged 87.4 square feet per acre, an increase from 86.7 in 2005.

• Across Arkansas, 60 percent of upland forest land stands had >50 percent of stand basal area in hardwoods. In contrast, 40 percent was in upland forest land stands with >50 percent of stand basal area in softwoods.

• Mortality was a large disturbance factor. There were 3.6 million acres of forest land which lost 10–19 percent of their basal area due to some type of tree death. Another 1.4 million acres was in forest land where 20–29 percent of stand basal area was lost to mortality.

• Cutting was an important disturbance factor in Arkansas. Since the 2005 survey, 3.2 million acres underwent some form of cutting. A total of 2.9 million acres had more than 10 percent of basal area removed.

Arkansas River at Van Buren, AR. (photo courtesy of wikimedia.org)

INTRODUCTION

This report presents the findings of the ninth forest survey (cycle 9) of Arkansas (survey year dated 2010). The survey presents estimates based upon the second full cycle of data of the fixed-plot sample design that was implemented in 2000. Trend information in the report is based on comparisons with cycle 8 data (survey year dated 2005). The estimates for the 2005 survey have been modified slightly since published in the 2005 report (Rosson and Rose 2010), so the current numbers may not match those previously published. When comparisons are made, the revised 2005 numbers are used; however, it should be noted that the 2005 report was based on timberland whereas the current report is based on forest land. This report does not include the Geography Section of the 2005 report; users can refer to that report for population and climate information. More detailed information concerning methods and trends are provided in the methods section of the appendix.

Numerous publications have been produced from previous State surveys of Arkansas. Except for the first survey, all other Arkansas surveys were summarized into a document such as this, commonly referred to as a State analytical report. The first survey of Arkansas, in 1935, covered only the areas most highly affected by harvesting in the early part of the 20th Century: the Mississippi River Delta, the south and southwest areas, and the Ouachita Mountain area. The north and northwest areas of the State were not surveyed until 1951. Manuscripts from the 1935 survey of Arkansas were numerous (U.S. Department of Agriculture Forest Service 1937b; U.S. Department of Agriculture Forest Service 1938a; U.S. Department of Agriculture Forest Service 1938b; Winters 1939). Additionally, two regional reports included information from the first survey of Arkansas (U.S. Department of Agriculture Forest Service 1937a; U.S. Department of Agriculture Forest Service 1937c). The first full survey of the State was done in 1951 (U.S. Department of Agriculture Forest Service 1953). Other State surveys were completed in 1959 (Sternitzke 1960), 1968 (Van Sickle 1970), 1978 (Van Hees 1980), 1988 (Beltz and others 1992), 1995 (Rosson 2002), and 2005 (Rosson and Rose 2010).

Arkansas' 75 counties were divided into five forest survey units (fig. 1): North Delta (11 counties), South Delta (10), Ouachita (10), Ozark (24), and Southwest (20). The unit boundaries have a reasonably close

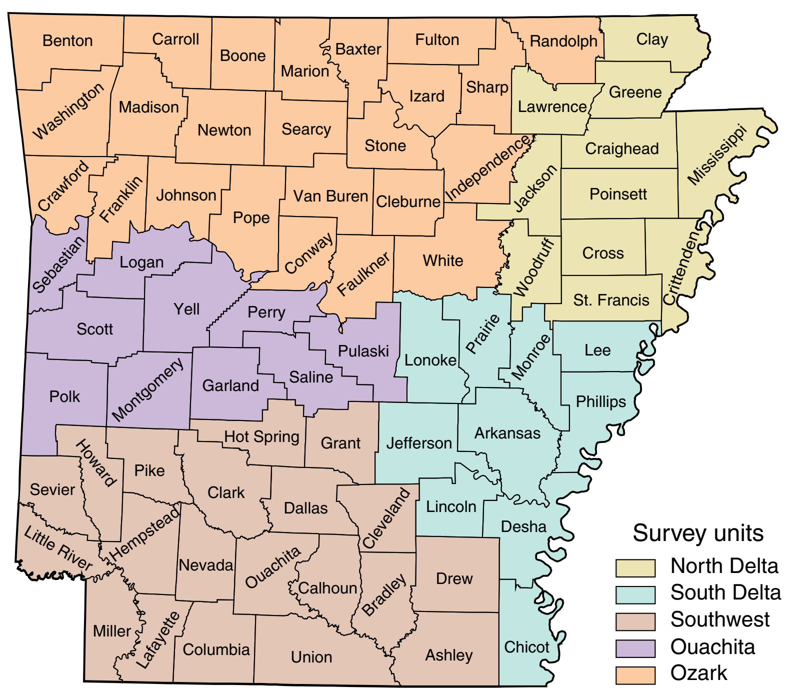


Figure 1—Forest survey units in Arkansas, 2010.

alignment with physiographic and physiognomic features of the State, and a beneficial corollary to that is that the units facilitate certain processes in data analysis (an increase in the homogeneity of the data within each survey unit decreases the variance).

Field work began on November 28, 2005 and was completed on October 25, 2010. The survey is dated 2010. During this new survey, 5,686 sample plots were visited by two-person field crews; there were 4,435 forest conditions on 3,510 sample plots. A total of 70,740 live trees ≥5.0 inches in diameter at breast height (d.b.h.) were measured. Additionally, 19,422 sapling-sized trees ≥1.0 inch but <5.0 inches d.b.h. were measured on smaller microplots (see appendix for techniques).

The tables and figures throughout the report show estimates for the 2010 survey and revised estimates from the 2005 survey. Estimates were derived from data processed and posted on April 12, 2012 for both the 2005 and 2010 surveys. The appendix describes survey methods and data reliability, defines terms, and lists tree species sampled in the survey. In addition, 68 supplemental resource tables for this report can be accessed at: http://srsfia2.fs.fed.us/states/arkansas.shtml.

Forked Mountain, Ouachita National Forest, Perry County, AR. (photo by James M. Guldin, Southern Research Station)

PHYSIOGRAPHY

The total earth cover inside the State boundary of Arkansas is 34.0 million acres (U.S. Department of Commerce, Bureau of the Census 2001). In area, it is the 29th largest of the 50 States. Arkansas is situated at the western edge of tree cover for the eastern deciduous forest and many species do not exist beyond the western State line. The landscape across the State is very diverse, ranging from lowlands in the south, deltaic expanses along the Mississippi River, and mountains and highlands to the west and north. The highest point in Arkansas is Magazine Mountain at 2,753 feet above sea level; the lowest point is the Ouachita River at 55 feet above sea level at the Louisiana State line. The mean elevation of Arkansas is 650 feet above sea level. Major rivers are the Arkansas River, Mississippi River, White River, and Ouachita River. Major lakes are Lake Ouachita and Bull Shoals Lake, both artificial impoundments on the Ouachita and White Rivers, respectively.

This diverse landscape is situated on three Physiographic Provinces: the Coastal Plain, the Ouachita, and the Ozark. Six Physiographic Sections occur on these three Provinces (fig. 2). The Section boundaries are similar to the Forest Inventory and Analysis (FIA) unit boundaries (fig. 1). The Salem/Springfield Plateaus, Boston Mountains, and Arkansas River Valley Sections are closely aligned with the FIA Ozark unit; the Ouachita Mountains Section is aligned with the Ouachita unit; the Coastal Plain Section aligns with the Southwest unit; and the Mississippi Alluvial Plain Section aligns with the North Delta and South Delta units. Because of past and continuous geological evolution and development, these regions have influenced the forest vegetation cover that currently occupies these lands. This section was adapted from Arkansas' Forests, 2005 (Rosson and Rose 2010).

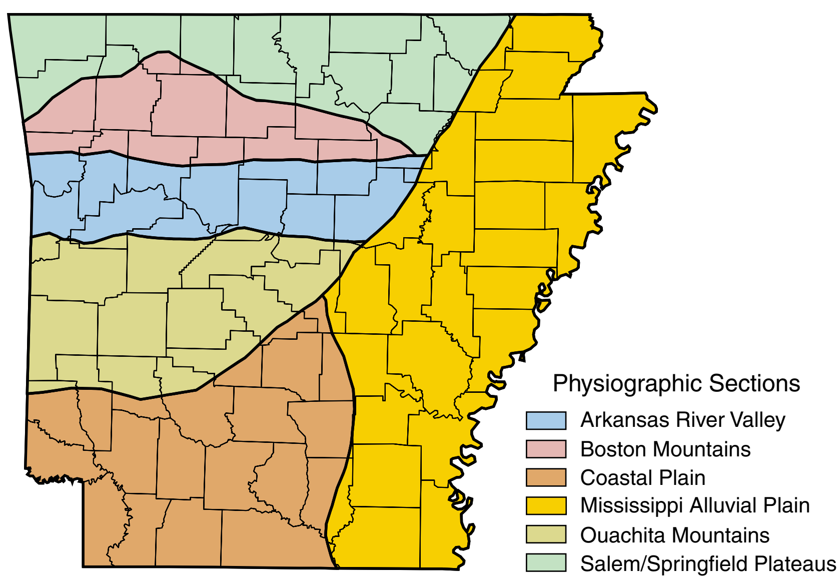


Figure 2—Physiographic Sections of the Ozark, Ouachita, and Coastal Plain Provinces of Arkansas. The Ozark Province includes Salem/Springfield Plateaus and Boston Mountains Sections; the Ouachita Province includes Arkansas River Valley and Ouachita Mountains Sections; the Coastal Plain Province includes the Mississippi Alluvial Plain and West Coastal Plain Sections. After Fenneman (1938).

FOREST AREA

In the 2000 Census, the total surface area inside the Arkansas State boundary was 34.0 million acres (U.S. Department of Commerce, Bureau of the Census 2001). The total land area for Arkansas was 33.3 million acres, the difference between total surface area and total land being the exclusion of bodies of water whose minimum size was arbitrarily set by definition (see definition of census water in glossary). In addition, FIA defines bodies of water between 1 and 4.5 acres in size, and streams 30 to 200 feet in width, as noncensus water (a type of nonforest land). This additional nonforest area, 166,500 acres, was included in table 1 to demonstrate additivity of all land categories (nonforest land + noncensus water + unproductive forest + reserved forest + timberland) to 33.3 million acres (table 1).

There were 18.7 million acres of forest land in Arkansas identified by the 2010 forest survey (table 1); this was 4.3 million acres more than in lands classed as nonforest (table 1). Total forest land comprised three components: timberland, reserved forest, and woodland (unproductive forest). The largest component was timberland, 18.5 million acres. The reserved forest category had 178,500 acres of which 74 percent was in the Ozark unit. Woodland existed on 36,600 acres; 67 percent of this acreage was in the Ozark unit. A combination of site characteristics (shallow nutrient-poor soils, southern exposures, high summer temperatures, and low levels of precipitation) were the primary reasons for unproductive forests in the Ozark unit.

The estimate of Arkansas' original forest cover was 32.0 million acres with almost 96 percent of all land in the State covered by forest (Davis 1983). In sharp contrast, today's forests cover only 56 percent of Arkansas' land area. By the 1920s (just before the first forest survey), land clearing had already reduced the State's forested area to 22.0 million acres. Approximately 2.0 million acres were estimated to be in old growth across the State at this time (Davis 1983).

Table 1—Area by survey unit and land class, Arkansas, 2010

			Land class				
Survey unit	Total land area[a]	Total forest[b]	Timberland	Reserved forest	Unproductive forest	Noncensus water[c]	Nonforest
				thousand acres			
South Delta	4,565.7	1,389.1	1,389.1	0.0	0.0	33.3	3,143.3
North Delta	4,643.9	768.0	768.0	0.0	0.0	20.0	3,855.8
Southwest	8,768.1	6,811.5	6,811.5	0.0	0.0	39.1	1,917.5
Ouachita	4,750.4	3,373.9	3,315.4	46.3	12.2	23.0	1,353.5
Ozark	10,579.3	6,377.7	6,221.0	132.2	24.4	50.9	4,150.7
All units	33,307.4	18,720.1	18,505.0	178.5	36.6	166.5	14,420.8

Numbers in rows and columns may not sum to totals due to rounding.

0.0 = no sample for the cell or a value >0.0 but <0.05.

[a] Total land area = total forest + noncensus water + nonforest. Does not include 726,800 acres of census water (as defined by Forest Inventory and Analysis (FIA)). Total spatial area of Arkansas = 34,034,200 acres.

[b] Total forest = timberland + reserved forest + unproductive forest.

[c] Water defined by FIA as nonforest water (but classed by the U.S. Census as land).

Of the 18.7 million acres of forest land in Arkansas, most was in the Southwest and Ozark units (table 2). When compared by the proportion of forest land in relation to total land area in their respective survey unit, forest land made up 78 percent of the Southwest unit and only 60 percent of the Ozark unit.

The survey unit with the smallest amount of forest land was the North Delta, with 768,000 acres that make up only 17 percent of the respective unit; this amount also represents only 4 percent of all forest land in Arkansas (table 2). The South Delta unit had slightly more forest land, with 1.4 million acres. This was 30 percent of all land in the unit but only 7 percent of all forest land in the State. These two units are still rebounding from the conversion of forest land to an agriculture use that took place between 1890 and 1980. The most recent conversions to cropland were between the mid-1960s and late 1970s, to take advantage of high spikes in soybean prices during that period. For the most part, this practice left lands in forest that had soils with the poorest drainage characteristics or lands unprotected inside the levee system. However, some of the forest land that was cleared has not been suitable for sustainable crop production; some of these lands may revert naturally back to forest land, some have already been planted in trees, and others are available for restoration efforts. Over the past 30 years, conversions back to forest have been in small increments. In addition, recent interest in biofuel production may target some of these sites for fiber production. Switchgrass and cottonwood are two of the species of high interest in this endeavor.

The proportion of land area in forest land in Arkansas' 75 counties ranged from 5 percent to 92 percent. Throughout the State, a total of 20 counties had >75 percent of their land area in forest land (fig. 3). The Southwest Unit had the densest concentration of forest land in the State. Here, 11 counties had >75 percent of their land area in forest land. In comparison to the Southwest unit, the Ouachita had six counties and the Ozark only three counties with >75 percent forest land. Of all counties, four had densities higher than 90 percent: Calhoun, Dallas, and Grant in the Southwest unit; Newton in the Ozark unit. Dallas County had the highest density of forest land in the State with >92 percent of its land area in forest land.

Table 2—Area of forest land by survey unit, year of survey, and change, Arkansas, 2005 and 2010

Survey unit	Year 2005	Year 2010	Change
	thousand acres		
South Delta	1,296.7	1,389.1	92.4
North Delta	685.9	768.0	82.1
Southwest	6,752.9	6,811.5	58.6
Ouachita	3,321.5	3,373.9	52.4
Ozark	6,220.2	6,377.7	157.5
All units	18,277.2	18,720.1	442.9

Numbers in columns may not sum to totals due to rounding.

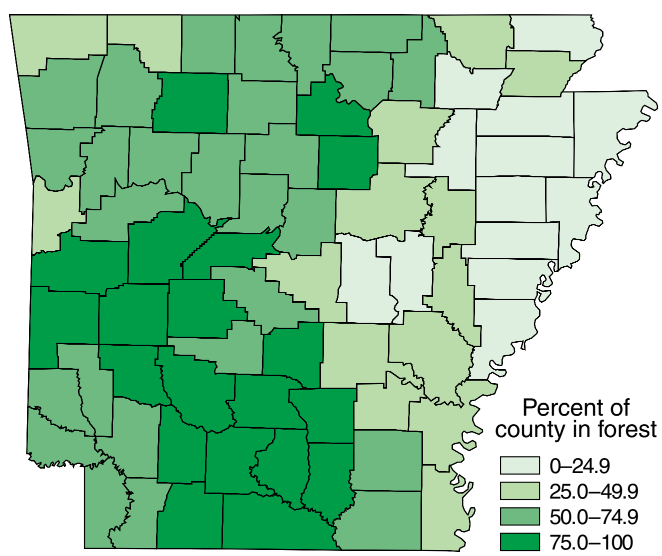


Figure 3—Percent of county area in forest land, Arkansas, 2010.

The least densely forested counties were in the two Delta units. Nine counties in the North Delta unit had <25 percent of land area in forest land. In the South Delta, four counties had forest land occupying <25 percent of land area. The least densely forested county in Arkansas was Mississippi County where only 5 percent of the county was in forest land. Opportunities may avail themselves in the future to return abandoned or unproductive agriculture land to forest in many counties of the Delta units. As discussed previously, much of the forest land cleared of forest was of marginal value in crop production and would be far more economically viable and ecologically sustainable if converted back to bottomland hardwood forests.

Statewide, forest land has increased by 442,900 acres since the 2005 survey (table 2). Thirty-six percent of this overall increase was in the Ozark unit (157,500 acres). However, on a relative basis, the largest increase was in the North Delta, with a 12-percent increase (82,100 acres). The lowest relative increase was in the Southwest unit, with a 1-percent increase (58,600 acres).

While the overall net change between 2005 and 2010 was a 442,900-acre increase, not all Arkansas counties had increases. Of Arkansas' 75 counties, 55 had increases and 20 had decreases (table 3). The top 10 counties that increased accounted for 207,800 acres of the increase. The 20 counties that lost forest land accounted for a 109,200-acre loss. The 55 counties that had increases accounted for a 552,200-acre gain in forest land.

Shortleaf pine-bluestem habitat restoration, Ouachita National Forest, Scott County, AR. (photo by James M. Guldin, Southern Research Station)

Table 3—Area of forest land by county, year of survey, change, and percent of total forest (2010), Arkansas, 2005 and 2010

County	Year 2005	Year 2010	Change	Total forest	County	Year 2005	Year 2010	Change	Total forest
	- - - - - *thousand acres*		- - - - -	*percent*		- - - - - *thousand acres*		- - - - -	*percent*
Arkansas	194.2	191.5	-2.7	1.0	Lee	81.1	91.3	10.2	0.5
Ashley	395.7	400.9	5.2	2.1	Lincoln	133.4	142.7	9.3	0.8
Baxter	222.6	221.6	-1.0	1.2	Little River	168.9	184.8	16.0	1.0
Benton	216.1	219.7	3.6	1.2	Logan	255.8	261.0	5.2	1.4
Boone	165.4	170.7	5.3	0.9	Lonoke	107.4	116.4	9.0	0.6
Bradley	356.3	354.6	-1.7	1.9	Madison	330.9	326.5	-4.4	1.7
Calhoun	360.2	350.1	-10.1	1.9	Marion	253.3	247.9	-5.4	1.3
Carroll	204.2	205.3	1.2	1.1	Miller	176.9	207.8	30.9	1.1
Chicot	112.5	122.6	10.1	0.7	Mississippi	27.5	28.9	1.4	0.2
Clark	449.7	458.1	8.5	2.4	Monroe	162.0	174.8	12.8	0.9
Clay	65.3	70.8	5.6	0.4	Montgomery	414.0	403.1	-10.9	2.2
Cleburne	271.0	288.6	17.6	1.5	Nevada	325.5	324.3	-1.2	1.7
Cleveland	306.5	317.5	11.0	1.7	Newton	427.2	440.3	13.0	2.4
Columbia	428.6	431.5	3.0	2.3	Ouachita	406.2	406.3	0.0	2.2
Conway	183.6	199.8	16.2	1.1	Perry	278.1	267.1	-11.0	1.4
Craighead	52.8	57.9	5.1	0.3	Phillips	81.5	94.6	13.2	0.5
Crawford	197.7	209.2	11.5	1.1	Pike	298.1	297.6	-0.4	1.6
Crittenden	46.2	38.6	-7.6	0.2	Poinsett	55.8	67.8	12.0	0.4
Cross	48.3	50.0	1.7	0.3	Polk	423.0	423.2	0.3	2.3
Dallas	389.2	400.3	11.1	2.1	Pope	367.5	383.2	15.7	2.0
Desha	140.2	151.4	11.2	0.8	Prairie	93.3	105.8	12.5	0.6
Drew	391.4	397.9	6.6	2.1	Pulaski	203.8	228.3	24.4	1.2
Faulkner	215.1	213.6	-1.4	1.1	Randolph	189.3	181.1	-8.2	1.0
Franklin	215.2	223.1	7.9	1.2	St. Francis	56.9	79.8	22.8	0.4
Fulton	203.9	234.5	30.6	1.3	Saline	313.1	311.5	-1.6	1.7
Garland	364.0	379.9	15.9	2.0	Scott	455.9	460.7	4.8	2.5
Grant	384.9	392.0	7.0	2.1	Searcy	286.0	287.2	1.2	1.5
Greene	96.1	102.7	6.6	0.5	Sebastian	148.4	158.1	9.7	0.8
Hempstead	306.7	299.7	-7.0	1.6	Sevier	234.2	238.5	4.3	1.3
Hot Spring	256.7	251.3	-5.4	1.3	Sharp	261.8	259.1	-2.7	1.4
Howard	303.1	284.1	-18.9	1.5	Stone	330.2	346.7	16.4	1.9
Independence	208.9	225.9	17.0	1.2	Union	602.1	607.9	5.8	3.2
Izard	250.4	253.5	3.0	1.4	Van Buren	356.8	355.3	-1.4	1.9
Jackson	60.2	71.9	11.7	0.4	Washington	323.4	331.2	7.8	1.8
Jefferson	191.1	198.0	6.9	1.1	White	242.1	252.9	10.8	1.4
Johnson	297.6	300.8	3.2	1.6	Woodruff	99.9	114.6	14.6	0.6
Lafayette	212.3	206.1	-6.2	1.1	Yell	465.3	481.0	15.7	2.6
Lawrence	76.9	84.9	8.0	0.5	All counties	18,277.2	18,720.1	442.9	100.0

Numbers in rows and columns may not sum to totals due to rounding.

Most of the changes in forest land area were driven by additions or diversions to agriculture. The 570,700-acre addition of forest land from agriculture land was offset somewhat by the 184,900 acres of forest land that was cleared and put into agriculture use. This left an overall net change of a 385,800-acre increase for this land use (table 4).

In land uses other than agriculture, there was a fairly even balance between diversions and additions. Net change was a 42,300-acre increase in forest land (table 4). In additions to forest land, most prior land uses (54 percent) were from some type of developed land such as that for residential or industrial purposes, while 26 percent came from some type of rights-of-way such as roads, railroads, utility lines, etc. The remaining 20 percent came from water. In contrast, most of the diverted forest land went to some type of developed use (40 percent) or to rights-of-way (42 percent); the remaining 18 percent went to water (table 4).

Regionally, most of the additions and diversions to and from forest land occurred in the Ozark unit. Again, most of this land use change activity was to or from the agriculture land use component (table 4). Much of the agriculture land reverting to forest may have been a result of the recent economic downturn and the subsequent impact on marginal farming operations.

Table 4—Changes in forest land by forest survey unit, Arkansas, 2005–10

Survey unit	Change[a]	Total additions	Additions: Agriculture[b]	Additions: Other[c]	Total diversions	Diversions: Agriculture[b]	Diversions: Other[c]
	thousand acres						
South Delta	74.6	105.2	85.1	20.1	-30.6	-8.3	-22.4
North Delta	66.9	76.5	62.9	13.6	-9.6	-2.0	-7.6
Southwest	58.3	147.8	91.5	56.3	-89.5	-55.1	-34.5
Ouachita	58.0	129.0	76.9	52.1	-71.0	-24.1	-46.9
Ozark	170.2	330.3	254.2	76.1	-160.1	-95.4	-64.7
All units	428.0	788.9	570.7	218.3	-360.9	-184.9	-176.0

Note: The net changes from diversions and additions in this table do not equal the real change in forest land area between the 2005 and 2010 surveys because of an incomplete remeasure of all plots (see methods section in Appendix).

Numbers in rows and columns may not sum to totals due to rounding.

[a] Change is the difference between diversions (a loss) and additions (a gain) of forest land.

[b] Agriculture includes cropland, pasture, idle farmland, orchards, Christmas tree plantations, maintained wildlife openings, and rangeland.

[c] Other includes business, manufacturing, residential, rights-of-way (roads, railways, power/oil/gas lines, and canals), recreation areas (parks, skiing, golf courses, etc.), mining, and water.

OWNERSHIP

This report characterizes forest land ownership into four major groups: national forest, other public, forest industry, and nonindustrial private forest (NIPF). These are the same groupings that Southern Research Station (SRS)-FIA has historically reported over the last 50+ years. Recently, forest industry in the Southern States has divested much of its forest land, and two types of investment organizations have made entry into some of these available lands. One type of investment group is the timberland investment management organization (TIMO); the second type is real estate investment trusts (REIT).

Legislation was passed by Congress in the 1970s to encourage investors to diversify their portfolios. This, along with a restructuring of corporate tax legislation, resulted in the development of TIMO and timber REIT investment vehicles. Since the enactment of this legislation, there has been a gradual shift from U.S. forest lands being managed by large and small firms in forest industry toward management by an increasing number of TIMOs and REITs. A study by Yale's Program on Private Forest Certification in 2002 showed 14.4 billion dollars of U.S. forest land was being managed by TIMO groups. Another later study showed that by 2005 the total investment in TIMOs and timber REITs exceeded 25 billion dollars (Hickman 2007).

A TIMO and a timber REIT have the responsibility of serving as a broker for investors, and they usually apply modern portfolio theory to decisions of when to buy, hold, harvest, or sell forest land. These investment decisions may differ from traditional longer-term forest industry goals and thus raise concerns that forest fragmentation may increase and sustainability

Cavity trees in a nesting cluster for the endangered red-cockaded woodpecker in the shortleaf pine-bluestem management area, Ouachita National Forest, Scott County, AR. (photo by James M. Guldin, Southern Research Station) of forest resources might become more problematic. In order to track the impact of these types of ownerships on forest resources, it is essential that these new ownerships are identified. During data collection for the 2005 and 2010 Arkansas surveys, the TIMO and REIT investment groups were not specifically identified as an ownership class and therefore were not listed and reported in the tables as an ownership category. Because of the many different ways that ownership information is recorded and stored in courthouses across the State, these types of ownerships were often not readily identifiable in available public courthouse records. Hopefully, future refinements in the collection of FIA ownership information will differentiate these two important ownership categories. Currently, some of the TIMO and REIT acreage may be in the NIPF category and some still in the forest industry category. One reason for this confusion is that a forest industry entity retains the ownership designation under a timber REIT structure.

The majority of Arkansas' forest land was in NIPF ownership, 11.3 million acres (table 5). Slightly over half (60 percent) of all forest land was in this class, an ownership pattern typical of many Southern States. Forest industry ranked second with 3.7 million acres (20 percent) followed by national forest with 2.5 million acres (13 percent) (see important note about national forest acreage in the glossary under ownership). The other public ownership category had approximately 1.2 million acres in forest land area and together, with all national forest lands, public owned forest land was 3.7 million acres, close to 20 percent of all the State's forest land.

Interesting breakdowns of forest land by region were evident in the ownership categories. The highest proportion of NIPF ownership was in the North Delta unit, 79 percent (table 5), but even though this unit's proportion was highest, it also had the lowest amount of NIPF forest land, only 609,900 acres. The second highest proportion of NIPF forest land was in the Ozark unit, 76 percent. In addition, this unit also contained the highest amount of NIPF forest land, 4.8 million acres. Every county in Arkansas had some portion of its forest land held by an NIPF ownership interest. The range in NIPF proportions across the State was 5 to 100 percent. There were 56 counties with >50 percent of forest land

Table 5—Area of forest land by survey unit, ownership class, and change, Arkansas, 2005–10

		Ownership class							
	Total	National forest		Other public		Forest industry		NIPF	
Survey unit	2010	2010	Change	2010	Change	2010	Change	2010	Change
	thousand acres								
South Delta	1,389.1	23.9	-5.1	281.5	18.9	163.1	-28.6	920.7	107.2
North Delta	768.0	0.0	0.0	145.8	9.1	12.3	-7.6	609.9	80.7
Southwest	6,811.5	12.8	-6.1	241.7	23.5	2,812.6	-313.8	3,744.3	354.9
Ouachita	3,373.9	1,447.3	1.6	183.8	23.8	540.2	-65.0	1,202.6	92.1
Ozark	6,377.7	1,023.8	-1.6	302.2	19.2	210.6	14.5	4,841.1	125.4
All units	18,720.1	2,507.8	-11.2	1,155.0	94.4	3,738.8	-400.5	11,318.6	760.3

Numbers in rows and columns may not sum to totals due to rounding.
NIPF = nonindustrial private forest.
0.0 = no sample for the cell or a value >0.0 but <0.05.

in NIPF, 25 counties with >80 percent, and 12 counties with >90 percent. Four counties had 100 percent of forest land in NIPF ownership. Most of the counties with high-level NIPF proportions were in the Ozark unit. Of the 25 counties with >80 percent of forest land in NIPF, 13 were in the Ozark unit; the remaining counties were in the two Delta units (8 counties) and the Southwest unit (2 counties). In contrast, there were only three counties with <25 percent of forest land in NIPF ownership. Two of these were in the Ouachita unit where the relative proportion of national forest ownership was very high. The other one was in the North Delta unit where other public ownership was in high proportions.

All of the survey units had forest land in public ownership, but the majority was in the Ouachita and Ozark units. Eighty-one percent of public lands were in these two units, most of which were in national forests, 2.5 million acres (table 5). Across Arkansas, there were 28 counties with national forest ownership sampled in the forest survey. The range of national forest proportions in individual counties ranged from 0 to 86 percent. There were four counties with >50 percent of their forest land in national forest ownership; two were in the Ouachita unit and two were in the Ozark unit. One county in the Ouachita unit (Montgomery) had >80 percent of its forest land area in national forest. There were not any counties where the only ownership was in national forest.

The 1.2 million acres of other public forest land was fairly evenly distributed across the State. There were 58 counties with other public ownership of forest land. Across the State, the proportion of forest land, by county, in the other public category ranged from 0 to 95 percent. There were only two counties with other public ownership >50 percent of forest land, one in each Delta unit. It should be noted that not all other public lands were accounted for in the broad-scale forest survey used by FIA, so only those that were selected in the respective sample intensity were reported in the survey results. Small parcels of only a few hundred acres had a very high probability of being missed by the sample. Most of the other public forest land that was reported made up <10 percent of a respective county's forest land; there were 56 counties at this level of density. There were no counties with only forest land in other public ownership.

Most of the forest industry ownership in Arkansas was in the Southwest unit. There were 2.8 million acres there, 75 percent of all forest industry lands in the State. Seven counties had >50 percent of their forest land ownership held by forest industry. All of these were in the Southwest unit. Across the State, forest industry ownership ranged from 0 to 69 percent in individual counties. There were 44 counties in Arkansas that had some portion of their forest land in forest industry ownership. Twenty of these were in the Southwest unit. There were no counties with only forest industry ownership of forest land.

The area of forest land in public ownership has changed little since 2005, increasing by only 83,200 acres. This increase was spread fairly evenly across all of the survey units.

The most notable ownership change in area was in lands identified as forest industry or NIPF. Forest industry area decreased by 400,500 acres while NIPF increased by 760,000 acres. Most of this change occurred in the Southwest unit where 313,800 acres were lost in forest industry and 354,900 acres were gained in NIPF. This was most likely due to continued divestment of forest industry lands and these lands subsequently being switched to the NIPF category. It is likely that most of these lands went into TIMO or REIT ownership categories (see earlier ownership discussion).

FOREST-TYPE GROUPS

For Arkansas forests, the FIA program aggregated forest types into six forest-type groups (FTG) to summarize results. A forest type was derived by computer algorithm for each plot (or plot condition if more than one condition per plot was present) during data processing. This forest type was based on the relative dominance of each species present (or plurality if there was not a majority present). The relative stocking assignment for each species was used to rank its dominance and assign a respective forest type name, usually based upon the dominant first, second, or third species. Similar forest types were then grouped together into larger aggregations called a forest-type group. For example, plots that were dominant with shortleaf pine and plots that were dominant with loblolly pine were aggregated together into the loblolly-shortleaf pine FTG. The maps in figures 4 and 5 illustrate the breakout of the two predominant components in the loblolly-shortleaf FTG. In this instance, the loblolly pine forest type and shortleaf pine forest type occupy different habitats across the State. Most notably, the loblolly pine type is most prevalent on the Coastal Plain Physiographic Section (fig. 4), while the shortleaf pine type is most prevalent on the Ouachita Mountains Physiographic Section (fig. 5). There is also considerable overlap of the two types across the Ouachita Mountains Physiographic Section, but the shortleaf type drops out considerably within the Coastal Plain Physiographic Section.

With the exception of suppressed trees, the dominant and codominant trees are the most likely to be disturbed or removed from a stand, either naturally or through cutting. Therefore, forest type classification was sensitive to disturbances of dominant and codominant trees on a sample plot. There were five potential reasons for shifts in forest type acreage across Arkansas. First, selective cutting of pine, without ensuring adequate pine regeneration, could result in a shift of pine forest types toward the hardwood types. Second, clearcutting a forest stand (especially those with substantial hardwoods) and replanting with pine could increase the pine types. Third, diversion or

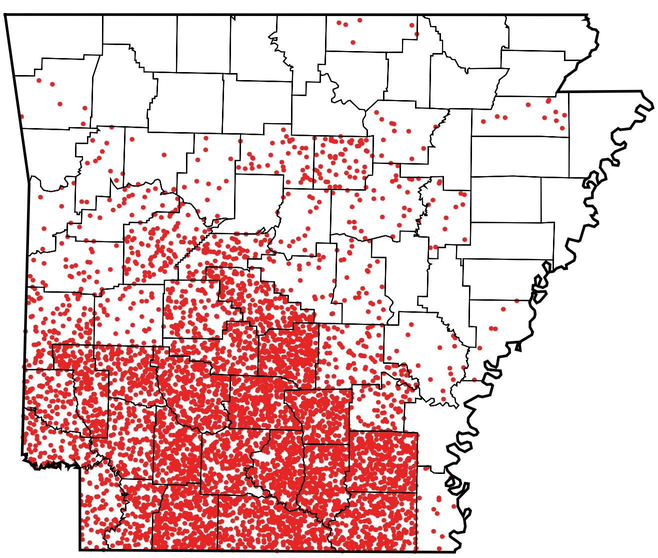


Figure 4—Spatial distribution of loblolly pine forest type, Arkansas, 2010. Each dot represents 1,000 acres of loblolly pine type. See methods section for map methodology.

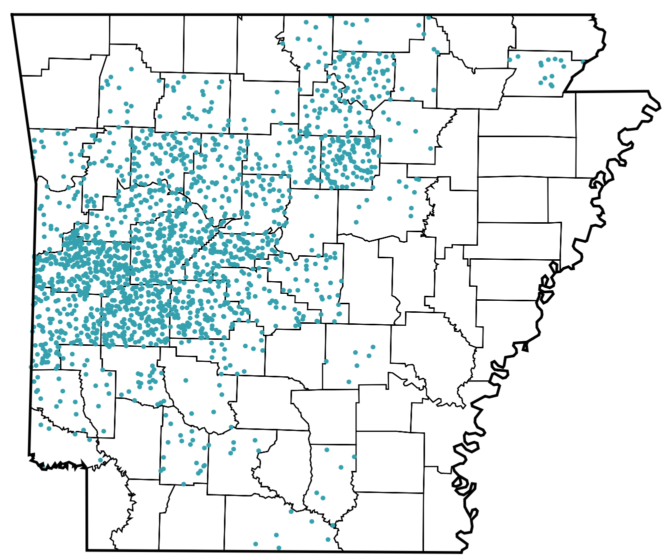


Figure 5—Spatial distribution of shortleaf pine forest type, Arkansas, 2010. Each dot represents 1,000 acres of shortleaf pine type. See methods section for map methodology.

additions of forest land acreage could show a respective decline or increase in a particular type; so, losses or gains of forest land area must be considered when portraying forest type shifts. Fourth, fire activity could shift types toward pine while fire suppression could shift types toward hardwood, especially in younger stands or those stands with substantial advanced regeneration. Fifth, because forest type classification is an artificial classification system, forest types are not always separate and discrete entities. Rather, they may merge and flow into each other, sometimes with considerable overlap, forming, in these instances, a continuum. Thus, since type categories are defined by discrete boundaries, a slight shift of species dominance across these arbitrary thresholds may give a false impression of dramatic changes in forest type acreage between surveys.

The Morris Pine, a 300+ year-old loblolly pine growing on the Levi Wilcoxon Demonstration Forest in Ashley County, AR. (photo by Don C. Bragg, Southern Research Station)

The dominant FTG in Arkansas continues to be oak-hickory, covering 7.7 million acres of forest land (table 6). Sixty-one percent of the oak-hickory FTG was in the Ozark unit (table 6). In this unit, 4.7 million acres were in this FTG, 73 percent of all Ozark forest land. In general, lower average annual precipitation and predominance of limestone-derived soil types of this unit favor some of the more xeric hardwoods (e.g., post oak and black hickory) over the conifers, especially as stands become older.

Ranked second in dominance was the loblolly-shortleaf pine FTG, covering 5.5 million acres (table 6). This FTG was dominant both in the Ouachita and Southwest units, where shortleaf pine was the dominant species in the Ouachita Mountains and loblolly pine was dominant on the Coastal Plain (figs. 4 and 5). This FTG made up 29 percent of the forest land area in the State. There were 3.4 million acres of the loblolly-shortleaf FTG in the Southwest unit, 51 percent of all forest land there. Forest industry operations were most active in this unit, and establishment and management of loblolly pine plantations dominated forestry activity. There were 1.4 million acres of the loblolly-shortleaf FTG in the Ouachita unit, 41 percent of the forest land there (table 6). Together, the number one and two ranked FTGs (oak-hickory and loblolly-shortleaf) covered 71 percent of Arkansas forest land.

The oak-pine FTG ranked third with 2.1 million acres; it was most dominant in the Southwest unit (893,400 acres). Following behind the oak-pine FTG was the oak-gum-cypress, elm-ash-cottonwood, eastern redcedar, and nonstocked forest lands. Based on the proportion of forest land, the bottomland hardwoods were most dominant in the North and South Delta units of

Table 6—Area of forest land by survey unit, forest-type group, and change, Arkansas, 2005–10

		Forest-type group															
	Total	Loblolly-shortleaf		Eastern redcedar		Oak-pine		Oak-hickory		Oak-gum-cypress		Elm-ash-cottonwood		Miscellaneous hardwood		Non-stocked	
Survey unit	2010	2010	Change	2010	Change	2010	Change	2010	Change	2010	Change	2010	Change	2010	Change	2010	Change
								thousand acres									
South Delta	1,389.1	179.5	37.6	0.0	0.0	13.3	-21.4	270.9	-42.9	528.3	93.6	365.4	9.3	0.0	0.0	31.6	16.1
North Delta	768.0	18.5	10.0	4.1	4.1	9.6	-5.7	275.4	-19.6	287.8	53.8	161.4	29.6	3.4	3.4	7.9	6.4
Southwest	6,811.5	3,443.5	143.5	1.5	0.0	893.4	3.7	1,303.6	-169.4	959.0	97.8	148.9	-0.7	10.5	4.6	51.0	-20.9
Ouachita	3,373.9	1,371.4	14.1	50.9	9.7	552.3	30.5	1,193.4	-15.9	113.2	28.9	82.2	2.1	7.5	4.5	2.9	-21.5
Ozark	6,377.7	481.3	2.7	243.7	30.6	632.2	61.1	4,667.3	41.5	162.9	37.3	134.1	-29.6	20.7	10.0	35.4	9.9
All units	18,720.1	5,494.4	207.9	300.3	44.4	2,100.8	68.3	7,710.5	-212.3	2,051.2	311.4	892.0	10.7	42.2	22.5	128.8	-9.9

Numbers in rows and columns may not sum to totals due to rounding.
0.0 = no sample for the cell or a value >0.0 but <0.05.

the Mississippi River Delta (table 6). The eastern redcedar forest type was most prevalent in the Ozark unit, where 81 percent of the type occurred. It was more common on the Salem Plateaus Province portion of the Ozark unit and especially common on abandoned agricultural lands and woodlands and glades with thin soils.

Three notable changes occurred in forest land area of respective FTG's in Arkansas since the 2005 survey. First, the oak-hickory FTG decreased, and second, the loblolly-shortleaf FTG increased by a similar amount of slightly more than 200,000 acres (table 6). This has been an ongoing phenomenon in Arkansas as softwoods became preferred over hardwoods in intensive forest management activity. Most of the decrease in the oak-hickory FTG and increase in the loblolly-shortleaf FTG occurred in the Southwest unit, the region of highest forestry activity (table 6). Third, the oak-gum-cypress FTG increased 311,400 acres. Often, many forested acres that were cleared for agriculture find their way back into a forest land use after many years of marginal agricultural crop production. These are situations where sites may be more ecologically suited for forest land use rather than cropland. The acreage increases in oak-gum-cypress were spread fairly evenly across all the survey units, with the highest changes in the South Delta and Southwest units.

Changes in FTGs by ownership were driven by activity on forest industry and NIPF forest land (table 7). Seventy-three percent of the oak-hickory FTG decline was on forest industry lands, while 94 percent of the increase in loblolly-shortleaf FTG was on NIPF. This increase was most likely due to forest industry ownership switching to NIPF through divestments. Almost all of the increase in oak-gum-cypress was on NIPF lands, supporting the idea of marginal agriculture lands converting to forest land.

Table 7—Area of forest land by forest-type group, ownership class, and change, Arkansas, 2005–10

	Ownership class							
	National forest		Other public		Forest industry		NIPF	
Forest-type group	2010	Change	2010	Change	2010	Change	2010	Change
	thousand acres							
Loblolly-shortleaf	872.2	46.1	91.1	-1.5	2,350.2	-32.1	2,180.9	195.4
Eastern redcedar	0.9	0.0	21.8	-2.4	6.0	6.0	271.6	40.8
Oak-pine	367.3	-30.6	104.6	30.8	311.4	-95.6	1,317.4	163.7
Oak-hickory	1,234.5	-48.7	311.1	19.1	566.5	-155.4	5,598.4	-27.4
Oak-gum-cypress	4.4	3.0	480.7	68.9	391.6	-54.9	1,174.4	294.4
Elm-ash-cottonwood	10.6	3.3	144.2	-5.5	82.4	-43.2	654.9	56.1
Miscellaneous hardwood	12.0	12.0	0.0	0.0	0.0	-6.0	30.1	16.5
Nonstocked	5.8	3.8	1.4	-15.0	30.7	-19.3	90.9	20.7
All groups	2,507.8	-11.2	1,155.0	94.4	3,738.8	-400.5	11,318.6	760.3

Numbers in columns may not sum to totals due to rounding.
NIPF = nonindustrial private forest.
0.0 = no sample for the cell or a value >0.0 but <0.05.

Several interesting patterns emerged regarding the distribution of the six FTGs by ownership. Most of the oak-hickory FTG continues to be held by NIPF owners (table 7). These 5.6 million acres were 30 percent of all forest land in the State and 49 percent of all NIPF forest land. Another interesting facet about NIPF forest land was that 1.8 million acres of bottomland hardwoods (oak-gum-cypress and elm-ash-cottonwood) were held on these lands, 62 percent of all bottomland hardwood stands in the State (table 7).

The forest industry ownership category was unique in that it held 43 percent of the loblolly-shortleaf pine FTG in Arkansas. Forest industry held 2.4 million acres of this FTG, 63 percent of all forest industry lands (table 7).

Another unique aspect of ownership patterns was that most of the other public lands were in the bottomland hardwood FTGs, 54 percent of all forest land in this ownership category. In contrast, there were virtually no bottomland hardwoods in national forest ownership. Here, the majority of forest land was in the oak-hickory FTG (49 percent) followed by loblolly-shortleaf pine (35 percent) (table 7). The decline in the oak-pine and oak-hickory FTGs on national forest lands, coupled with the increase in the loblolly-shortleaf FTG, is largely due to the successful expansion of pine-bluestem woodland habitat in the western Ouachita Mountains for purposes of recovery of the endangered red-cockaded woodpecker (*Picoides borealis*), a species which thrives in open pine woodlands.

Indication of actively managed NIPF land, Nevada County, AR. (photo by Teddy Reynolds, Reynolds Forestry Consulting and Real Estate)

STAND INVENTORY

The 2010 inventory of live-tree volume on forest land for Arkansas was 29.2 billion cubic feet, an increase of 6 percent since the 2005 inventory. Sixty-two percent of the inventory was in hardwoods, 38 percent was in softwoods. The sawtimber inventory was 97.2 billion board feet; 47 percent of this was in softwoods and 53 percent was in hardwoods. This new sawtimber inventory was 10 percent more than that of the 2005 inventory. The gains in cubic and board-foot volume can be attributed to a gradual increase in forest land area and a maturing of the timber resource over time.

Softwood Inventory

Arkansas' 2010 softwood volume was 11,218.1 million cubic feet. This was a 750.8-million cubic foot increase (7 percent) since the 2005 inventory (table 8). Most of this increase was spread evenly across the Southwest, Ouachita, and Ozark survey units. The only loss in softwood volume was recorded in the South Delta unit.

The spatial distribution of the softwood volume was mostly concentrated in southwest Arkansas in the Southwest and Ouachita survey units (fig. 6). Overall, shortleaf pine occurred in the northern portion of this distribution area, while loblolly pine was most prevalent in the South. Highest concentrations of softwood volume were in Scott County, in the far west, and in a band across Columbia, Union, Calhoun, Bradley, Drew, Dallas, and Grant Counties.

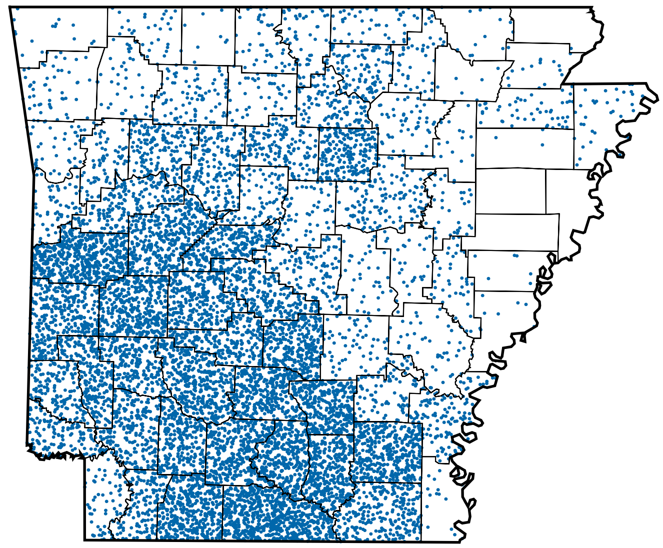


Figure 6—Softwood volume, Arkansas, 2010. Each dot represents 1,000,000 cubic feet of live-tree volume. See methods section for map methodology.

The highest amounts of softwood volume were in the NIPF and forest industry ownerships (table 9). However, a 568.2-million cubic foot increase on NIPF lands was in

Table 8—Live-tree volume of softwoods on forest land by survey unit, year of survey, and change, Arkansas, 2005 and 2010

Survey unit	Year 2005	Year 2010	Change
	million cubic feet		
South Delta	457.8	451.6	-6.2
North Delta	117.1	160.6	43.5
Southwest	5,706.1	5,953.2	247.1
Ouachita	2,628.2	2,856.8	228.6
Ozark	1,558.1	1,795.9	237.7
All units	10,467.3	11,218.1	750.8

Numbers in columns may not sum to totals due to rounding.

Table 9—Live-tree volume of softwoods on forest land by ownership class, year of survey, and change, Arkansas, 2005 and 2010

Ownership class	Year 2005	Year 2010	Change
	million cubic feet		
National forest	1,999.2	2,176.9	177.7
Other public	513.6	619.8	106.2
Forest industry	3,305.5	3,204.2	-101.3
NIPF	4,649.0	5,217.2	568.2
All classes	10,467.3	11,218.1	750.8

Numbers in columns may not sum to totals due to rounding.

NIPF = nonindustrial private forest.

sharp contrast to a 101.3-million cubic foot loss on forest industry lands. Much of this may be attributed to forest industry divestments resulting in a change of ownership (also, see table 5). National forest lands held a substantial amount of softwood volume along with a 177.7-million cubic foot increase since 2005. Most of this increase can be attributed to a maturing of the shortleaf pine resource and the growth of loblolly pine plantations brought into the public domain from forest industry ownership.

The 7-percent softwood volume increase since the 2005 survey was distributed across all diameters (fig. 7). The highest gains were in the 8- to 12-inch diameter classes. Other diameters with notable gains were the 18- and 24-inch classes. Although only small gains were evident in some classes, none showed a decline since the 2005 survey, evidence of a maturing inventory and stable recruitment regimen in the smaller diameter classes.

The softwood sawtimber inventory was 45,871.0 million board feet (table 10). There was an increase of 3,692.9 million board feet (9 percent) since the 2005 inventory, further signs of a maturing softwood resource. Fifty-six percent of the volume was in the Southwest unit, but compared to the sizeable amount of the inventory, the gains were small, increasing slightly <3 percent. In contrast, the increases in softwood sawtimber volume in the Ozark unit were 26 percent followed by a 14-percent increase in the Ouachita unit. These factors point to a maturing of stands with softwoods in these two units where decreases in harvesting have been in effect on national forest lands.

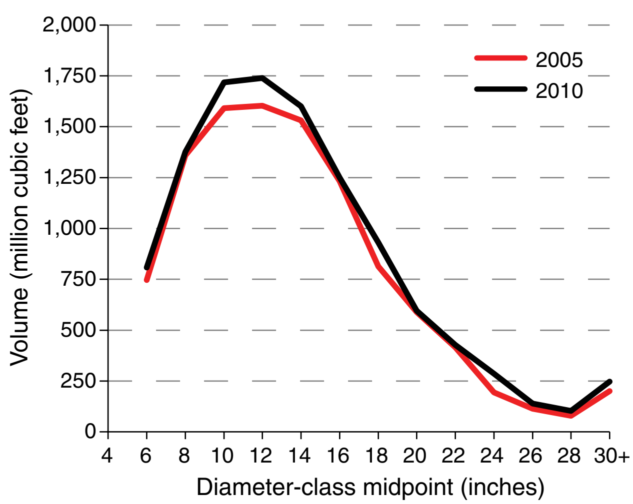


Figure 7—Softwood live-tree volume by diameter class, Arkansas, 2005 and 2010. The labels on the x-axis are the 2-inch d.b.h. midpoints, e.g., the 6-inch d.b.h. midpoint value represents trees ranging from 5.0–6.9 inches d.b.h.

Table 10—Board-foot volume of softwoods on forest land by survey unit, year of survey, and change, Arkansas, 2005 and 2010

	Year		
Survey unit	2005	2010	Change
	million board feet[a]		
South Delta	1,958.1	2,090.3	132.2
North Delta	550.2	707.3	157.1
Southwest	24,826.4	25,540.9	714.5
Ouachita	10,088.2	11,520.6	1,432.4
Ozark	4,755.1	6,011.9	1,256.7
All units	42,178.1	45,871.0	3,692.9

Numbers in columns may not sum to totals due to rounding.

[a] International ¼-inch rule.

A notable change occurred in the softwood sawtimber volume on forest industry lands (table 11), with a 649.2-million board foot decrease in this ownership. Again, the divestment of forest industry lands has resulted in some of these lands changing to NIPF ownership. Much of the 15-percent increase in softwood sawtimber volume on NIPF lands may be attributed to this change. However, the 12-percent increases on national forest lands is primarily a result of the maturing resource.

Hardwood Inventory

The hardwood inventory volume for 2010 was 18,006.3 million cubic feet (table 12). This represented a 5-percent increase since the 2005 inventory. However, this increase was not evenly distributed across the survey units as was the case with softwoods. With hardwoods, 48 percent occurred in the Ozark unit. However, this was not unusual since 41 percent of Arkansas' hardwood inventory was in this unit.

The spatial distribution of the hardwood inventory was spread across the State (fig. 8). Noted areas with the highest

Table 11—Board-foot volume of sawtimber softwoods on forest land by ownership class, year of survey, and change, Arkansas, 2005 and 2010

Ownership class	Year 2005	Year 2010	Change
	million board feet[a]		
National forest	8,303.0	9,296.3	993.3
Other public	2,460.3	3,002.8	542.5
Forest industry	12,919.2	12,270.0	-649.2
NIPF	18,495.5	21,301.8	2,806.3
All classes	42,178.1	45,871.0	3,692.9

Numbers in columns may not sum to totals due to rounding.

NIPF = nonindustrial private forest.

[a] International ¼-inch rule.

Table 12—Live-tree volume of hardwoods on forest land by survey unit, year of survey, and change, Arkansas, 2005 and 2010

Survey unit	Year 2005	Year 2010	Change
	million cubic feet		
South Delta	2,219.5	2,259.0	39.6
North Delta	1,171.2	1,319.6	148.4
Southwest	4,506.1	4,664.1	158.0
Ouachita	2,171.3	2,295.8	124.5
Ozark	7,034.7	7,467.9	433.2
All units	17,102.7	18,006.3	903.7

Numbers in columns may not sum to totals due to rounding.

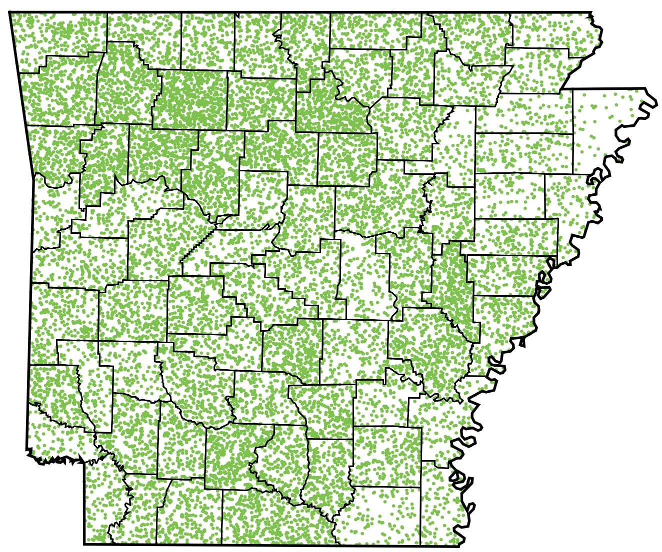


Figure 8—Hardwood volume, Arkansas, 2010. Each dot represents 1,000,000 cubic feet of live-tree volume. See methods section for map methodology.

concentrations of hardwood volume were across the northwest, east-central, and south-central Arkansas. Specific counties with these high concentrations of volume included Newton, Johnson, Franklin, and Stone in the northwest, Monroe in the east, and Grant and Ouachita in the South.

Most of the hardwood volume was on NIPF lands, 11,433.7 million cubic feet (table 13). This was 63 percent of the total hardwood resource. Additionally, this ownership realized the majority of hardwood volume increase since 2005, 1,045.8 million cubic feet. Forest industry lost 393.2 million cubic feet of hardwood volume since the 2005 inventory due to industry divestment and the strong emphasis toward pine plantation management in Arkansas.

The 5-percent increase in hardwood volume since 2005 was distributed across the entire range of diameters with the exception of the 6-, 10-, and 26-inch diameter classes (fig. 9). The largest decrease was in the 10-inch class, a decrease from 2,312.9 to 2,266.0 million cubic feet.

The hardwood sawtimber inventory was 51,366.7 million board feet (table 14). This was a 4,898.8-million board foot increase since 2005. Sixty-four percent of the hardwood sawtimber resource was in the Ozark

Table 13—Live-tree volume of hardwoods on forest land by ownership class, year of survey, and change, Arkansas, 2005 and 2010

Ownership class	Year 2005	Year 2010	Change
	million cubic feet		
National forest	2,535.8	2,604.2	68.4
Other public	2,003.3	2,185.9	182.6
Forest industry	2,175.6	1,782.5	-393.2
NIPF	10,387.9	11,433.7	1,045.8
All classes	17,102.7	18,006.3	903.7

Numbers in columns may not sum to totals due to rounding.

NIPF = nonindustrial private forest.

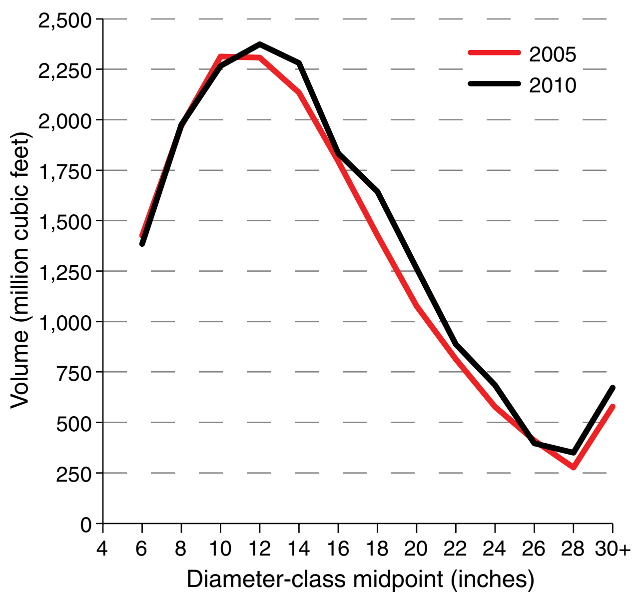


Figure 9—Hardwood live-tree volume by diameter class, Arkansas, 2005 and 2010. The labels on the x-axis are the 2-inch d.b.h. midpoints, e.g., the 6-inch d.b.h. midpoint value represents trees ranging from 5.0–6.9 inches d.b.h.

Table 14—Board-foot volume of hardwoods on forest land by survey unit, year of survey, and change, Arkansas, 2005 and 2010

Survey unit	Year 2005	Year 2010	Change
	million board feet[a]		
South Delta	8,102.4	8,314.8	212.4
North Delta	3,644.1	4,385.2	741.0
Southwest	13,077.3	14,132.9	1,055.6
Ouachita	4,911.7	5,691.0	779.3
Ozark	16,732.3	18,842.9	2,110.6
All units	46,467.8	51,366.7	4,898.8

Numbers in columns may not sum to totals due to rounding.

[a] International ¼-inch rule.

and Southwest units. The Ozark unit dominated in the hardwood sawtimber resource because of the unit's size, as well as the prevalence of mature hardwood forest stands and habitat and topographic conditions that are more suited to hardwoods than for intensive pine plantation management. Likewise, most of the increases in the hardwood inventory were in the same survey units, with the Ozark unit adding almost two times the volume to its inventory since 2005 over the Southwest unit. However, despite the emphasis on pine management in the Southwest unit, there was still an appreciable hardwood inventory there, especially in the major and minor stream bottoms of the Red, Ouachita, and Saline river systems.

Marking for harvest in 75th year of the study, Good Farm Forestry Forty Demonstration, Crossett Experimental Forest, Ashley County, AR. (photo by James M. Guldin, Southern Research Station)

Most of the hardwood sawtimber resource was on NIPF lands, 31,109.7 million board feet (61 percent). Interestingly, both national forest and other public lands contained more of the hardwood sawtimber resource than forest industry (table 15). The hardwood sawtimber inventory declined on forest industry lands by 1,309.2 million board feet since the 2005 inventory. This was the only ownership to have a decrease in hardwood sawtimber. Again, this was mostly due to forest industry divestments and emphasis on pine management at the expense of hardwoods.

Species Volume

All of the softwood species increased in volume since the 2005 inventory (fig. 10). Loblolly pine increased the most, from 6.1 to 6.5 billion cubic feet. It appears shortleaf pine has finally stopped its decline since the 1980s. This is the first survey since 1988 where it has shown an inventory increase; since 2005, volume increased from 3.5 to 3.7 billion cubic feet. However, this may be a sign of a maturing shortleaf resource rather than an increase in the distribution of shortleaf stands. Future surveys will provide more information on the status of shortleaf in Arkansas. Most of the decrease in shortleaf pine in Arkansas was because loblolly pine has been favored in pine management options. Stands that had shortleaf pine as a major stand component and were clearcut were usually replaced with loblolly pine. This was most common in southern Arkansas where artificial regeneration methods were commonly employed.

Table 15—Board-foot volume of sawtimber hardwoods on forest land by ownership class, year of survey, and change, Arkansas, 2005 and 2010

Ownership class	Year 2005	Year 2010	Change
	million board feet[a]		
National forest	6,270.4	6,814.0	543.5
Other public	7,384.3	8,287.0	902.7
Forest industry	6,465.2	5,156.0	-1,309.2
NIPF	26,347.9	31,109.7	4,761.8
All classes	46,467.8	51,366.7	4,898.8

Numbers in columns may not sum to totals due to rounding.

NIPF = nonindustrial private forest.

[a] International ¼-inch rule.

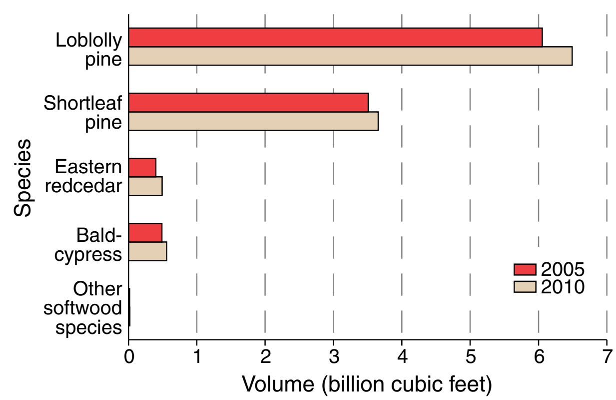


Figure 10—Softwood live-tree volume on forest land by species, Arkansas, 2005 and 2010.

The other red oak species group and select white oak species group dominated the hardwood volume in Arkansas (fig. 11). These two groups accounted for 35 percent of all hardwood volume. All species groups increased except for the willows and the sycamore-cottonwood group. The four oak groups are dominant in Arkansas, accounting for 56 percent of all hardwood volume.

In the inventory sample, there were 112 species of trees that were ≥5.0 inches in d.b.h. and contributed to the live-tree volume on forest land in the 2010 survey (table 16). The 75 top ranked species accounted for over 99 percent of the inventory. Forest inventories, such as this one for Arkansas, typically show an oligarchic distribution, e.g., most of the volume is concentrated in a very few dominant species.

The top five species accounted for 56 percent of the volume. The top 10 species accounted for 70 percent; adding another 10 species increased the volume to 25.5 billion cubic feet, 87 percent of the total volume in the State. The top 30 species made up 94 percent and the top 40 made up 97 percent. The remaining 72 species contributed only 3 percent to Arkansas' timber inventory.

As in the 2005 survey, 6 of the top 10 species were oaks, 2 were conifers, and the remaining 2 were sweetgum and black hickory (table 16). The predominant species in Arkansas is still loblolly pine. It still accounted for 22 percent of the total Arkansas inventory and 58 percent of the total softwood live-tree volume. The combination of its superb natural regeneration

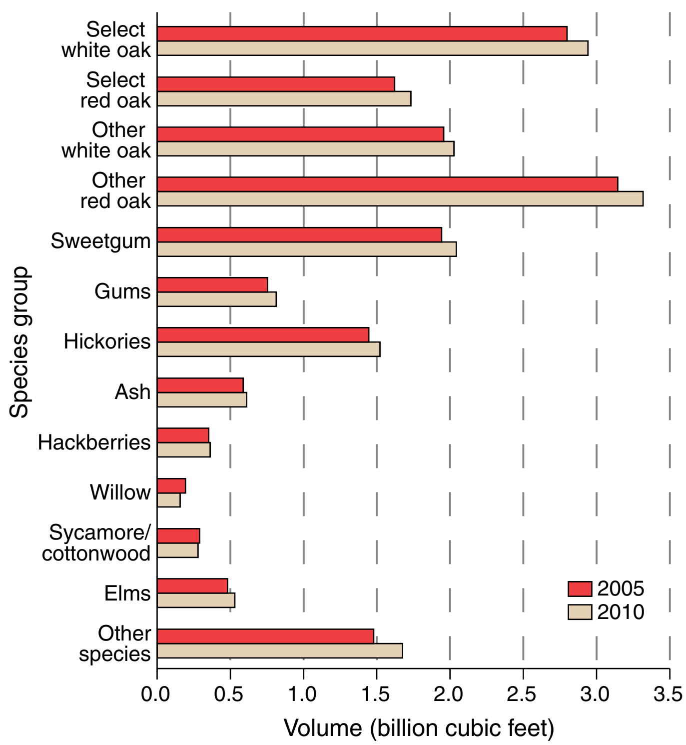


Figure 11—Hardwood live-tree volume on forest land by species group, Arkansas, 2005 and 2010. (See select white oak and select red oak definitions in the glossary).

Table 16—Ranking and comparison of live-tree volume by species on forest land, Arkansas, 2005 and 2010

Species	FIA species code	Live-tree volume 2005	2010	Change
		million cubic feet		
Loblolly pine	131	6,055.3	6,491.2	435.9
Shortleaf pine	110	3,507.0	3,655.8	148.8
White oak	802	2,628.6	2,759.6	131.0
Sweetgum	611	1,943.1	2,043.5	100.4
Post oak	835	1,470.1	1,512.7	42.6
Northern red oak	833	1,005.3	1,004.7	-0.7
Black oak	837	914.2	926.4	12.1
Southern red oak	812	847.9	850.5	2.6
Water oak	827	604.9	676.0	71.1
Black hickory	408	650.5	660.9	10.3
Cherrybark oak	813	558.4	653.1	94.8
Willow oak	831	537.9	590.6	52.7
Baldcypress	221	488.4	560.0	71.6
Mockernut hickory	409	484.9	520.3	35.4
Overcup oak	822	477.4	510.0	32.6
Eastern redcedar	68	399.8	492.6	92.8
Blackgum	693	460.0	482.4	22.3
Green ash	544	454.6	471.1	16.4
Water tupelo	691	228.5	328.7	100.2
Sugarberry	461	278.2	305.5	27.4
Red maple	316	267.9	274.0	6.1
Nuttall oak	828	229.0	269.7	40.7
Winged elm	971	214.6	224.7	10.1
Shagbark hickory	407	148.7	171.0	22.3
American sycamore	731	144.0	159.3	15.3
American elm	972	145.7	154.5	8.8
Water hickory	401	115.1	151.1	36.0
Black willow	922	152.3	150.8	-1.5
Black cherry	762	130.1	140.5	10.4
White ash	541	133.3	139.5	6.1
American beech	531	115.7	124.0	8.3
Eastern cottonwood	742	107.4	120.3	13.0
Slippery elm	975	82.8	115.9	33.1
Swamp chestnut oak	825	90.8	100.8	10.0
Florida maple	311	84.8	97.6	12.8
Bitternut hickory	402	70.2	92.3	22.1
Blackjack oak	824	103.8	91.2	-12.6
Pecan	404	83.0	91.1	8.2
Chinkapin oak	826	72.8	77.9	5.1
Black walnut	602	72.8	76.6	3.7
Shumard oak	834	58.8	74.9	16.2

continued

Table 16—Ranking and comparison of live-tree volume by species on forest land, Arkansas, 2005 and 2010 (continued)

Species	FIA species code	Live-tree volume 2005	2010	Change
		million cubic feet		
Pignut hickory	403	86.5	71.9	-14.6
Boxelder	313	53.1	70.6	17.5
Silver maple	317	31.1	57.1	26.0
Hackberry	462	74.8	56.1	-18.8
Common persimmon	521	54.0	54.8	0.7
Honeylocust	552	42.9	52.0	9.1
American hornbeam	391	35.9	45.5	9.6
American holly	591	42.5	45.1	2.6
Cedar elm	973	39.2	34.5	-4.7
Water-elm planertree	722	29.7	31.3	1.7
Sassafras	931	32.6	31.1	-1.4
Sweetbay	653	26.9	26.6	-0.3
River birch	373	26.5	25.6	-0.8
Eastern hophornbeam	701	24.6	25.2	0.6
Waterlocust	551	26.1	25.0	-1.1
Black locust	901	24.4	24.4	0.0
American basswood	951	16.2	19.4	3.2
Ashe juniper	61	16.8	18.5	1.6
Sugar maple	318	20.9	14.2	-6.7
Yellow-poplar	621	9.2	14.0	4.7
Flowering dogwood	491	13.6	12.0	-1.6
Osage-orange	641	7.3	10.6	3.3
Eastern redbud	471	8.0	9.6	1.6
Red mulberry	682	5.9	9.1	3.2
Serviceberry, spp.	356	4.1	4.5	0.5
Delta post oak	836	9.4	3.9	-5.5
Cucumbertree	651	3.7	3.8	0.2
Bur oak	823	6.6	3.6	-3.0
Umbrella magnolia	658	1.8	3.4	1.6
Laurel oak	820	6.0	2.8	-3.1
Butternut	601	3.4	2.8	-0.6
Nutmeg hickory	406	2.5	2.7	0.2
Ailanthus	341	1.4	2.6	1.1
Shellbark hickory	405	2.7	2.2	-0.5
Total top 75 species		27,409.0	29,209.9	1,800.0
Remaining 37 species		160.9	14.4	-146.5
Total		27,569.9	29,224.4	1,654.5

Note: Species are ranked by the 2010 inventory.
FIA = Forest Inventory and Analysis.
Numbers in columns may not sum to totals due to rounding.

capabilities and it also being the preferred species in forest industry and NIPF pine plantation management will likely mean its dominance will continue or increase over time (Schultz 1997). This is especially so on the Coastal Plain of southern Arkansas. The current loblolly pine volume of 6.5 billion cubic feet is striking when compared to the second dominant tree in the State, shortleaf pine; it was almost double that of shortleaf. Even though it was ranked second, shortleaf still made up a very respectable 3.7 billion cubic feet of volume, much more than even the highest ranking hardwood. White oak ranked third over all species and first over the hardwoods with 2.8 billion cubic feet of volume. White oak still made up 9 percent of total volume in the State and 15 percent of all hardwood volume, no change since 2005.

Loblolly pine had the largest increase in volume since 2005, a 435.9-million cubic foot increase. Most of the species had increases since the 2005 survey. Of the top 40 species, only northern red oak, black willow, and blackjack oak showed decreases, and these were very small (table 16).

Marking for harvest in 75th year of the study, Poor Farm Forestry Forty Demonstration, Crossett Experimental Forest, Ashley County, AR. (photo by James M. Guldin, Southern Research Station)

Effective Density, Softwood

Although total volume characteristics provide much value in describing forest resources at the State level, this only provides a glimpse of the forest resource situation in a State. Breakdowns by State regions (survey units) also help illuminate more detailed resource traits. Another important technique that helps clarify resource characteristics is effective density analysis (adapted from Rosson and Rose 2010). This shows, rather vividly, how the State's resources are distributed across the landscape according to defined stand characteristics. For example, as previously pointed out, it is clear that forest land area was not evenly distributed across the landscape by ownership, forest-type group, or stand size. Likewise, resource attributes of forest land (i.e., live-tree volume) were not spread evenly across the landscape. Each forest stand is unique, which can be attributed to various factors such as disturbance history, stand density, stand basal area, stand age, stand structure, and stand species composition. Therefore, it becomes important to know how much of the State's volume is in these different types of stand classes. The resulting effective density graphs are important illustrations that describe the amount of forest land that was in a marginally productive status. These stands may represent understocked lands, or they may reflect a situation where the age structure indicates too many stands in the young age or early stand development stages, thus not contributing to the State's overall inventory. These effective density graphs show, dramatically, that a large proportion of the State's total live-tree (or sawtimber) volumes was on only a small proportion of Arkansas' forest land. In contrast, a large amount of forest land was in stands that only contributed a very small amount of volume to the inventory.

Arkansas' 11.2 billion cubic feet of live-tree softwood volume was not evenly spread across all forest land. The distribution of this variation in softwood volume, by stand yield classes, across the landscape is quite dramatic (fig. 12). The y-axis represents the type of stand by volume per acre classes, ranging from <500 cubic feet per acre to stands with ≥2,000 cubic feet per acre. Clearly, two-thirds of Arkansas' forest land was composed of stands that had <500 cubic feet per acre of softwood live-tree volume. Eight percent of the softwood volume was in these types of stands. These stands included forest land where no

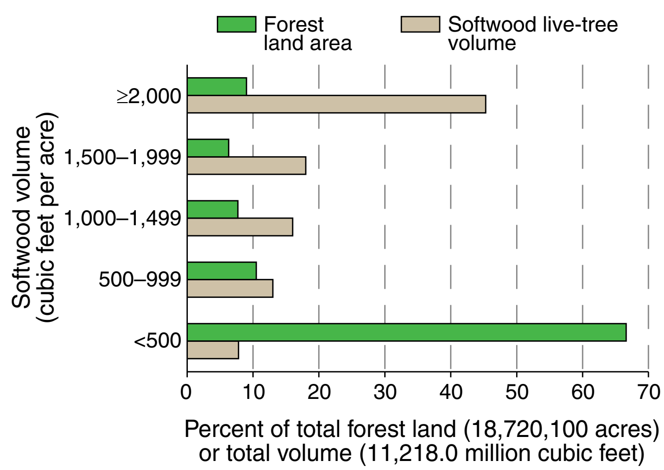


Figure 12—Effective density for live-tree softwood volume by cubic feet per acre class, Arkansas, 2010.

softwoods were present, stands with a very minor component of softwood volume, and pine plantations with little (or no) volume because they are still in the early development stages. In contrast, forest land stands with large amounts of softwood volume (stands with ≥2,000 cubic feet per acre) contained 45 percent of the States softwood volume but occurred on only 9 percent of the State's forest land. Furthermore, combining the highest stand classes showed that 15 percent of Arkansas' forest land held 63 percent of the State's softwood volume. This shows that there may be opportunity to improve the stocking levels on several million acres of forest land, suitable for softwoods, in Arkansas.

As expected, softwood sawtimber volume shows a similar pattern; large amounts of forest land acreage with little softwood sawtimber volume and small amounts of forest land acreage with large amounts of sawtimber (fig. 13). Approximately 65 percent of Arkansas' forest land had <2 percent of the softwood sawtimber volume. These were stands with <1,000 board feet per acre. At the other end of the spectrum were stands that had ≥9,000 board feet per acre. Only 9 percent of Arkansas' forest land was in this class, but 55 percent of softwood sawtimber volume was contained there. The combination of the two highest per-acre volume classes showed that 67 percent of softwood sawtimber volume was on only 13 percent of Arkansas' forest land.

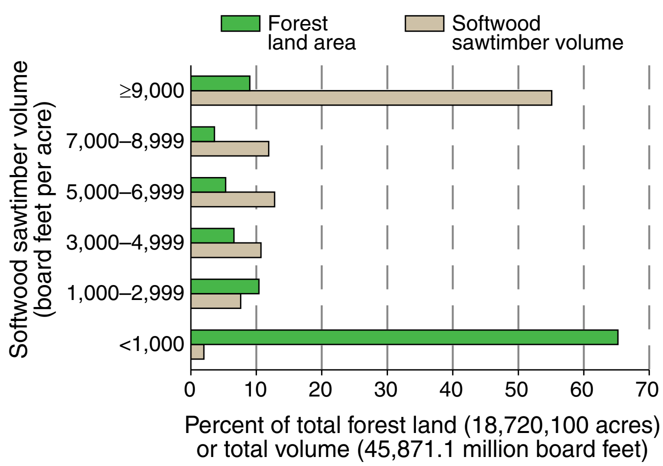


Figure 13—Effective density for softwood sawtimber volume by board feet per acre class, Arkansas, 2010.

Effective Density, Hardwood

Hardwood volumes show a similar pattern as that of softwoods, many acres with low volume and few acres containing most of the volume. Stands with <500 cubic feet of hardwood live-tree volume occupied 45 percent of Arkansas' forest land but supported only 6 percent of all the hardwood live-tree volume. In contrast (and also similar to the pattern seen in softwoods), 47 percent of hardwood live-tree volume was on 15 percent of forest land; these are stands that have ≥2,000 cubic feet per acre of hardwood volume (fig. 14).

The effective density graph for hardwood sawtimber showed a similar but more elevated pattern to that of live-tree hardwood volume. On the lower end of the spectrum, 63 percent of Arkansas forest land had <1,000 board feet per acre of hardwood sawtimber, 5 percent of the total hardwood sawtimber resource. In contrast, only 4 percent of forest land held 34 percent of the hardwood sawtimber volume, which was in stands with ≥9,000 board feet per acre. Combining categories showed that 83 percent of Arkansas' forest land was in stands with <3,000 board feet per acre in hardwoods, and these types of stands supported only 26 percent of the State's hardwood sawtimber volume (fig. 15).

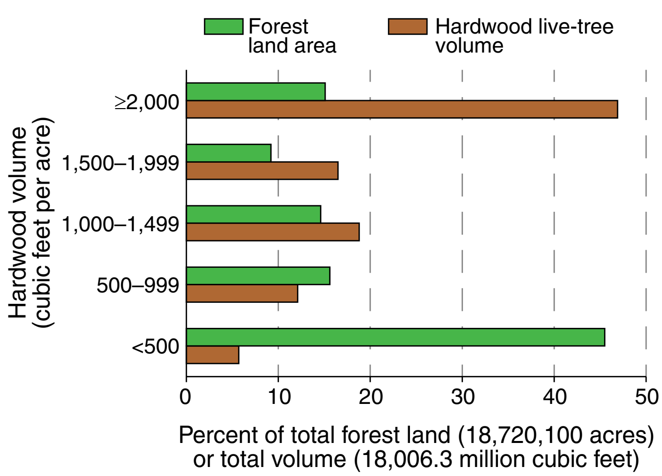


Figure 14—Effective density for live-tree hardwood volume by cubic feet per acre class, Arkansas, 2010.

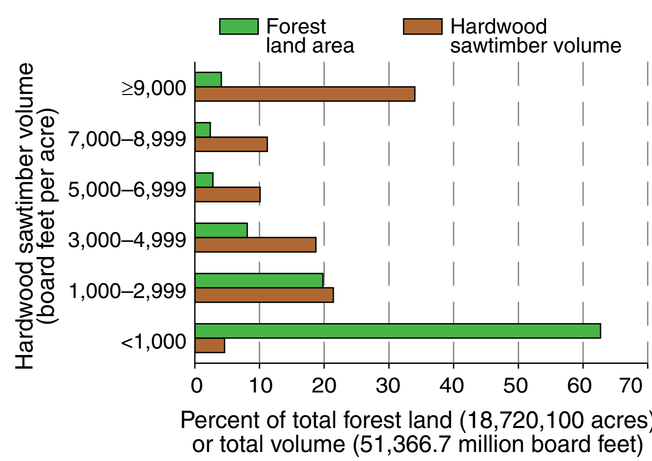


Figure 15—Effective density for hardwood sawtimber volume by board feet per acre class, Arkansas, 2010.

GROWTH, REMOVALS, AND MORTALITY

There are three major components of change in the forest inventory: growth of volume, removal of volume by means of cutting/harvesting or land-use change, and tree mortality (and subsequent loss of volume). The most reliable estimates of growth, removals, and mortality come from the remeasurement of plots, i.e., plots that were measured at time 1 and then remeasured at time 2. In such a continuous forest inventory scenario, all trees tallied at time 1 are accounted for at the second measurement and they either grew, were removed, or died. In addition, new trees may grow into the plot (ingrowth). An accounting of all these components results in a net change of the inventory; this results in an increase, a decrease, or no change in the inventory.

Even though a new sample design was installed in 2005, the growth, removals, and mortality estimates for 2005 were based on a remeasurement of the variable radius plots from the previous 1995 sample design (Rosson 2002). Because growth, removals, and mortality estimates were derived from a substantially different design for the 2005 inventory, no comparison was made in the growth estimates between the 2005 and 2010 surveys. See the methods section (Appendix A) for more details regarding growth, removals, and mortality.

Growth

Between 2005 and 2010, Arkansas' forest land inventory grew at the rate of 1.2 billion cubic feet per year. Softwood growth was 52 percent higher than hardwood growth, 750.2 versus 492.1 million cubic feet per year (table 17). Sixty-six percent of softwood growth was in the Southwest unit, 491.5 million cubic feet per year. Next was the Ouachita unit, contributing another 18 percent of softwood growth. Together, these two units accounted for 84 percent of Arkansas' softwood growth. The high amounts of softwood growth in the Southwest unit can be attributed to the high levels of forest management practices favoring pine. Large areas of plantations in early stages of development commonly grow at higher rates.

Table 17—Average net annual growth, removals, and mortality of live trees on forest land by survey unit and by softwoods and hardwoods, Arkansas, 2005–10

	Net growth		Removals		Mortality	
Survey unit	Softwood	Hardwood	Softwood	Hardwood	Softwood	Hardwood
			miillion cubic feet			
South Delta	28.9	56.7	22.9	50.2	1.4	24.6
North Delta	9.6	35.7	2.0	8.9	0.0	17.2
Southwest	491.5	178.5	404.1	142.3	26.7	41.6
Ouachita	134.6	55.0	82.4	34.6	15.8	24.5
Ozark	85.6	166.1	36.7	74.5	12.8	62.5
All units	750.2	492.1	548.1	310.5	56.8	170.5

Numbers in columns may not sum to totals due to rounding.

0.0 = no sample for the cell or a value >0.0 but <0.05.

Forty-four percent of softwood growth was in forest industry ownership (table 18). The same proportion of growth occurred on NIPF-owned forest land. Together, these two owner groups accounted for 88 percent of softwood growth. As forest industry continues divesting forest land holdings over time, a larger proportion of growth will switch to the NIPF ownership.

As would be expected, the loblolly-shortleaf pine FTG accounted for the majority of softwood growth (table 19). This group accounted for 81 percent of the net annual growth. Very little softwood growth occurred in stands with a pine mixture (oak-pine and oak-hickory), mostly because pine is such a minor component of these types.

Table 18—Average net annual growth, removals, and mortality of live trees on forest land by ownership class and by softwoods and hardwoods, Arkansas, 2005–10

Ownership class[a]	Net growth		Removals		Mortality	
	Softwood	Hardwood	Softwood	Hardwood	Softwood	Hardwood
	million cubic feet					
National forest	68.1	34.3	25.2	8.3	13.0	28.8
Other public	20.8	36.6	6.2	7.3	1.9	25.1
Forest industry	330.9	75.4	286.3	90.1	13.3	18.1
NIPF	330.4	345.9	230.4	204.8	28.5	98.5
All classes	750.2	492.1	548.1	310.5	56.8	170.5

Numbers in columns may not sum to totals due to rounding.

NIPF = nonindustrial private forest.

[a] Ownership at the end of the 2005 survey.

Table 19—Average net annual growth, removals, and mortality of live trees on forest land by forest-type group and by softwoods and hardwoods, Arkansas, 2005–10

Forest-type group[a]	Net growth		Removals		Mortality	
	Softwood	Hardwood	Softwood	Hardwood	Softwood	Hardwood
	million cubic feet					
Loblolly-shortleaf pine	604.8	46.5	347.6	59.9	38.8	9.8
Eastern redcedar	9.9	1.7	0.9	0.4	0.4	1.4
Oak-pine	68.3	42.9	72.8	29.1	9.6	13.6
Oak-hickory	40.0	239.7	111.6	136.3	7.3	79.7
Oak-gum-cypress	24.9	118.5	6.6	36.8	0.4	43.5
Elm-ash-cottonwood	1.4	42.4	3.6	38.0	0.1	21.0
Other types	0.3	0.0	1.2	3.6	0.0	0.7
Nonstocked	0.7	0.2	3.8	6.5	0.0	0.8
All groups	750.2	492.1	548.1	310.5	56.8	170.5

Numbers in columns may not sum to totals due to rounding.

0.0 = no sample for the cell or a value >0.0 but <0.05.

[a] Forest-type group at the end of the 2005 survey.

The softwood sawtimber growth showed similar patterns as live-tree growth (table 20). The inventory grew by 3.2 billion board feet per year. Most of this (2.0 billion board feet) was in the Southwest unit. The NIPF ownership had the most growth but was followed closely by forest industry, each accounting for 1.4 and 1.3 billion board feet per year, respectively (table 21). The amount of softwood sawtimber growth on forest industry lands is especially noteworthy, given that forest industry forest land holdings are less than one-half that of NIPF ownership.

The hardwood live-tree growth was 492.1 million cubic feet per year (table 17). Seventy percent of this growth was concentrated in the Southwest (36 percent) and Ozark (34 percent) units. It should be noted that per-acre growth rates may be higher than that reflected in the inventory

Table 20—Average net annual growth, removals, and mortality of sawtimber on forest land by survey unit and by softwoods and hardwoods, Arkansas, 2005–10

Survey unit	Net growth		Removals		Mortality	
	Softwood	Hardwood	Softwood	Hardwood	Softwood	Hardwood
	million board feet[a]					
South Delta	129.5	276.2	76.6	215.0	2.7	66.8
North Delta	32.1	153.6	10.6	36.4	0.0	48.5
Southwest	2,074.0	573.6	1,749.2	379.6	96.4	114.3
Ouachita	631.5	189.6	325.8	74.1	44.6	43.1
Ozark	352.4	656.3	107.4	215.9	34.8	115.5
All units	3,219.6	1,849.4	2,269.6	921.0	178.5	388.3

Numbers in columns may not sum to totals due to rounding.
0.0 = no sample for the cell or a value >0.0 but <0.05.
[a] International ¼-inch rule.

Table 21—Average net annual growth, removals, and mortality of sawtimber on forest land by ownership class and by softwoods and hardwoods, Arkansas, 2005–10

Ownership class[a]	Net growth		Removals		Mortality	
	Softwood	Hardwood	Softwood	Hardwood	Softwood	Hardwood
	million board feet[b]					
National forest	332.1	175.0	101.2	16.1	38.0	52.0
Other public	119.3	172.0	29.7	23.1	6.5	88.9
Forest industry	1,320.3	240.3	1,187.5	302.1	37.3	46.2
NIPF	1,447.9	1,262.2	951.2	579.7	96.7	201.2
All classes	3,219.6	1,849.4	2,269.6	921.0	178.5	388.3

Numbers in columns may not sum to totals due to rounding.
NIPF = nonindustrial private forest.
[a] Ownership at the end of the 2005 survey.
[b] International ¼-inch rule.

estimates (population level). For example, the Southwest unit population estimate is more than 3 times higher than that of the South Delta unit. However, the per-acre rate for the South Delta unit is roughly 41 cubic feet per acre per year, while that of the Southwest unit is 26 cubic feet per acre per year. There just happens to be many more forest land acres in the Southwest unit, and because of this (even though growing at a slower per-acre rate) the unit produces a much higher population estimate. The NIPF owner group had most of the growth, 70 percent (table 18). The oak-hickory and oak-gum-cypress FTGs accounted for 49 and 24 percent, respectively, of the live-tree hardwood growth (table 19).

The growth in hardwood sawtimber was 1.8 billion board feet per year (table 20). The Ozark unit had the most growth followed closely by the Southwest unit. The NIPF owner group accounted for most of the growth, 1.3 billion board feet per year; this was 68 percent of hardwood sawtimber growth (table 21).

Removals

Softwood live-tree removals were 548.1 million cubic feet per year, substantially lower than the 750.2 million cubic feet per year of growth (table 17). This means that more volume was being added to the inventory than being removed. Most of these removals were in the Southwest unit, 74 percent. Again, this was the result of the impact of timber harvest activity from forest industry and NIPF plantation management in this unit. Fifty-two percent of removals were on forest industry lands, 286.3 million cubic feet per year (table 18). An additional 42 percent of softwood removals came from NIPF lands. Combined, these two owner groups accounted for 94 percent of softwood live-tree removals. As expected, the majority of softwood removals were in the loblolly-shortleaf pine FTG (table 19). A sizeable amount of softwoods were removed from the oak-hickory FTG, 111.6 million cubic feet.

Softwood removals were most concentrated in southern Arkansas (fig. 16). Again, this is the area in Arkansas that supports the highest amounts of forest industry activity. Dallas County showed particularly high amounts of softwood removals.

Softwood sawtimber removals were 2.3 billion board feet per year (table 20). Patterns were similar to live-tree softwoods, with removals highest in the Southwest unit. The Southwest unit accounted for 77 percent of softwood sawtimber removals. By ownership, forest industry lands accounted for 52 percent of removals and NIPF lands 42 percent (table 21). These proportions between ownerships are expected to move to NIPF as forest industry divestments continue.

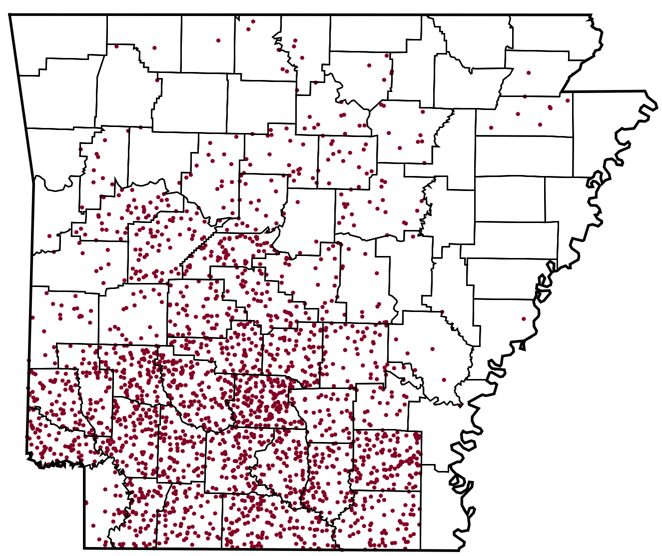


Figure 16—Softwood removals volume, Arkansas, 2010. Each dot represents 250,000 cubic feet of live-tree softwood volume removed per year. See methods section for map methodology.

Hardwood live-tree removals were much lower than that of softwoods. They averaged 310.5 million cubic feet per year across the State (table 17). There were no situations where hardwood removals exceeded growth. Highest removals were in the Southwest unit, 142.3 million cubic feet per year. The owner group with highest removals was NIPF, with 204.8 million cubic feet per year; this was 66 percent of all hardwood removals (table 18).

Although hardwood removals were much more widely and evenly dispersed across the State than that of softwoods, two areas of higher concentrations were evident (fig. 17): Arkansas County in the east and Yell County in the west. Regionally, hardwood removals were most highly concentrated in the south central region.

Hardwood sawtimber removals were only 41 percent of that in softwoods, 921.0 million board feet per year. There were no instances where hardwood removals exceeded growth. The Southwest unit accounted for 41 percent of removals, and the Ozark and South Delta units both accounted for 23 percent (table 20). Most of the hardwood sawtimber removals were on NIPF lands (63 percent), followed by forest industry with 33 percent (table 21).

Mortality

Total live-tree mortality was 227.3 million cubic feet per year, and 25 percent of this (56.8 million cubic feet per year) was in softwoods. Most of this softwood mortality was in the Southwest unit (47 percent), with the remainder spread fairly evenly between the Ouachita and Ozark survey units (table 17). Overall, softwood mortality was relatively low for the 2010 survey. Spatially, it was mostly confined to the south and western parts of the State (fig. 18). However, an unusually high amount of softwood mortality was noted in Fulton County in the north (fig. 18).

Most of the softwood mortality was in the NIPF owner group (50 percent), while the second and third ranked owner groups (national forest and forest industry) had 23 percent each of the total mortality (table 18). As expected, the loblolly-shortleaf pine FTG accounted for a large proportion of live-tree softwood mortality, 68 percent (table 19).

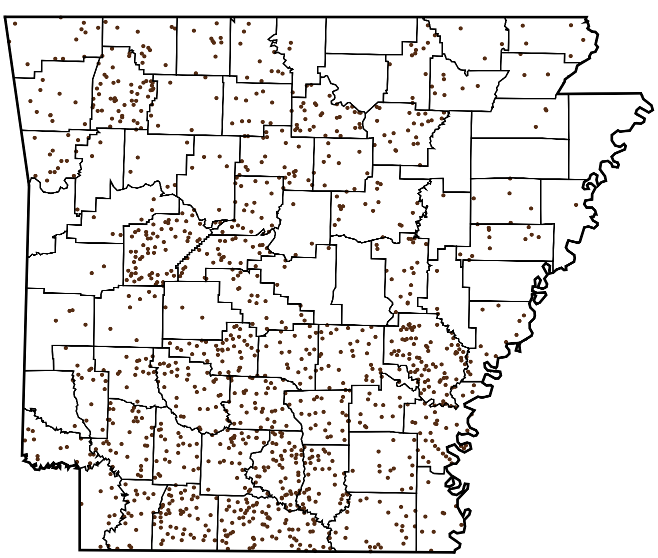


Figure 17—Hardwood removals volume, Arkansas, 2010. Each dot represents 250,000 cubic feet of live-tree hardwood volume removed per year. See methods section for map methodology.

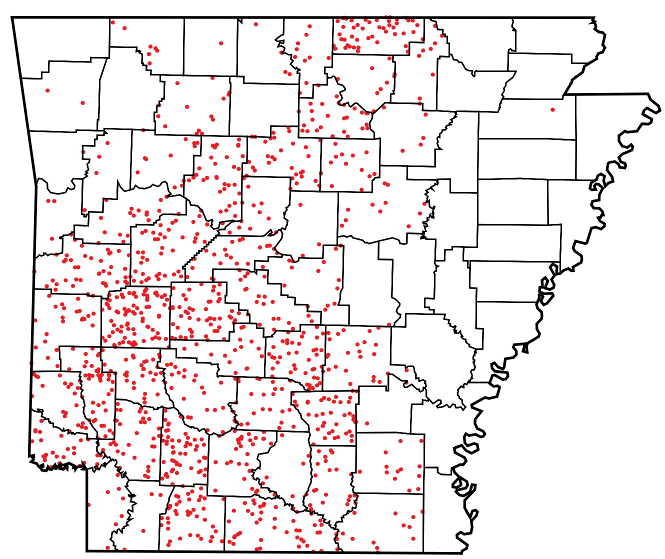


Figure 18—Softwood mortality volume, Arkansas, 2010. Each dot represents 50,000 cubic feet of live-tree softwood volume lost to mortality per year. See methods section for map methodology.

Hardwood mortality was 170.5 million cubic feet per year, with 37 percent in the Ozark unit (table 17). Much of the forest land in this area is made up of many oak species, and the oak-hickory FTG is dominant in occurrence. The second ranked unit was the Southwest; this unit had 24 percent of the mortality volume and together these two units made up 61 percent of hardwood mortality.

The NIPF owner group had a mortality rate of 98.5 million cubic feet per year, 58 percent of all hardwood mortality (table 18). Ranked second was national forests with 28.8 million cubic feet per year, 17 percent of all hardwood mortality. This was higher than its ownership proportion of 13 percent, indicating that hardwood mortality rates were slightly higher on national forests than on other ownerships, i.e., this particular ownership accounted for 13 percent of forest land area but had 17 percent of hardwood mortality. Hardwood mortality was spread widely across Arkansas, more so than softwood mortality (fig. 19). High concentrations appeared in Arkansas and Stone Counties.

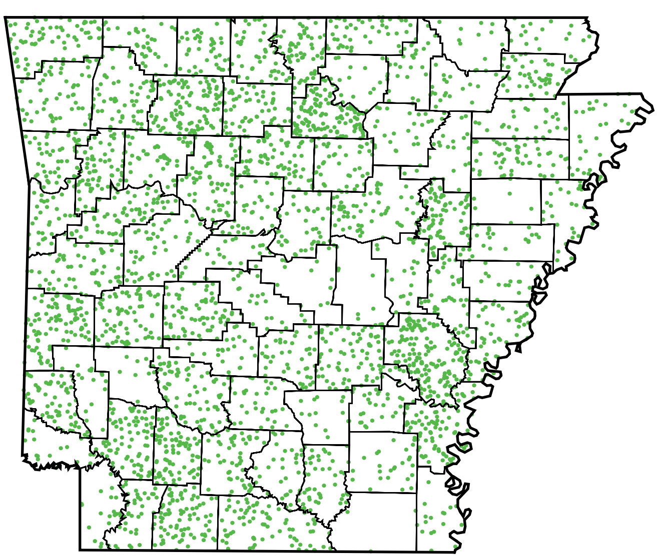


Figure 19—Hardwood mortality volume, Arkansas, 2010. Each dot represents 50,000 cubic feet of live-tree hardwood volume lost to mortality per year. See methods section for map methodology.

Species Growth, Removals, and Mortality

Twenty species accounted for 91 percent of all the live-tree growth in Arkansas (table 22). As expected, the rankings were similar to the live-tree volume rankings. Loblolly pine was the number one species and contributed 47 percent of all growth in the State. Ranked second was shortleaf

Table 22—Average net annual growth of live trees on forest land by species, Arkansas, 2005–10

Species	FIA species code	Growth
		million cubic feet
Loblolly pine	131	583.1
Shortleaf pine	110	121.1
Sweetgum	611	80.4
White oak	802	69.1
Post oak	835	34.8
Water oak	827	25.9
Eastern redcedar	68	25.1
Southern red oak	812	24.5
Cherrybark oak	813	22.6
Willow oak	831	21.3
Baldcypress	221	19.7
Black hickory	408	16.1
Green ash	544	12.5
Mockernut hickory	409	12.4
Blackgum	693	11.7
Overcup oak	822	10.9
Sugarberry	461	10.8
Water tupelo	691	10.8
Black oak	837	10.6
Red maple	316	9.8
Total top 20 species		1,133.1
Remaining species		109.1
Total		1,242.3

FIA = Forest Inventory and Analysis.

Numbers in columns may not sum to totals due to rounding.

pine, third was sweetgum, and fourth was white oak. Together, these four species accounted for 69 percent of live-tree growth in Arkansas.

Regarding removals, the top 20 species accounted for 95 percent of all removals (table 23). As with growth, loblolly and shortleaf pine were the number one and two species. Sweetgum and white oak ranked third and fourth, respectively. Together, these 4 species made up 74 percent of all the live-tree hardwood removals in Arkansas.

The top 20 species in mortality in Arkansas made up 85 percent of all mortality (table 24). However, the distribution of mortality among the top species was more even than that for growth or removals.

Table 23—Average net annual removals of live trees on forest land by species, Arkansas, 2005–10

Species	FIA species code	Removals
		million cubic feet
Loblolly pine	131	447.3
Shortleaf pine	110	95.5
Sweetgum	611	55.4
White oak	802	40.1
Post oak	835	22.9
Southern red oak	812	21.3
Water oak	827	17.9
Willow oak	831	17.0
Cherrybark oak	813	14.8
Northern red oak	833	11.9
Swamp cottonwood	744	10.6
Black hickory	408	10.2
Black oak	837	8.1
Mockernut hickory	409	7.6
Blackgum	693	6.8
Sugarberry	461	6.4
Red maple	316	5.8
American sycamore	731	5.2
Eastern redcedar	68	5.0
Green ash	544	4.7
Total top 20 species		814.3
Remaining species		44.3
Total		858.6

FIA = Forest Inventory and Analysis.

Numbers in columns may not sum to totals due to rounding.

Table 24—Average net annual mortality of live trees on forest land by species, Arkansas, 2005–10

Species	FIA species code	Mortality
		million cubic feet
Loblolly pine	131	29.9
Shortleaf pine	110	23.9
White oak	802	16.3
Northern red oak	833	15.5
Black oak	837	15.3
Sweetgum	611	13.8
Post oak	835	9.1
Southern red oak	812	8.9
Black willow	922	8.9
Water oak	827	8.5
Willow oak	831	6.6
Cherrybark oak	813	5.1
Winged elm	971	4.8
Green ash	544	4.7
Mockernut hickory	409	4.3
Red maple	316	4.2
Black hickory	408	3.7
Blackjack oak	824	3.2
Sugarberry	461	3.1
American elm	972	3.0
Total top 20 species		192.6
Remaining species		34.6
Total		227.3

FIA = Forest Inventory and Analysis.

Numbers in columns may not sum to totals due to rounding.

Instead of loblolly pine accounting for close to 50 percent of mortality, it accounted for only 13 percent of all mortality in the State. It was closely followed by shortleaf pine (11 percent), then white oak, and northern red oak, at 7 percent, each. Together, these 4 species made up 38 percent of the mortality in Arkansas.

Loblolly pine ranked high in the growth, removal, and mortality categories because it was the most dominant species, by volume, in the State. This is because it has been the most favored species in plantation establishment and also due to its natural ability to regenerate prolifically in nonintensive (natural) forestry. Therefore, because of its high amount of volume, it will naturally have correspondingly higher growth, removal, and mortality estimates. Even though the respective overall estimates of removals and mortality for loblolly pine are higher than those for other species, the ratio of removals (or mortality) to growth are much lower in loblolly pine than that of other species.

A special note regarding shortleaf pine: it was once the dominant conifer in Arkansas. However, because of historical harvesting activity and regeneration of harvested lands through plantation preferences (loblolly pine), it is now a distant second. Additionally, shortleaf pine removals exceeded growth for a period of time, indicating continuing population declines in this species in Arkansas. Population levels seem to have stabilized as of the 2010 survey. Future surveys will show whether the decline has stopped in Arkansas or if the species is still on a downward trend.

Effective Density, Growth

The net growth of softwoods and hardwoods in Arkansas was not evenly dispersed across all forest land. Depending on site conditions, stocking levels, past disturbance, etc., stands grew at different rates. The effective density analysis for growth was done on natural stands. Plantation stands were analyzed in the next section of the report. It is important to keep in mind that the total natural forest land area is included in the analysis that follows, for both softwoods and hardwoods. No attempt was made to define a stand as softwood or hardwood so stands that were composed of 100 percent hardwoods would show no growth in softwoods, and vice versa.

Eighty-three percent of Arkansas' natural forest land stands were growing <50 cubic feet of softwood volume per acre per year (fig. 20). Another 9 percent were growing

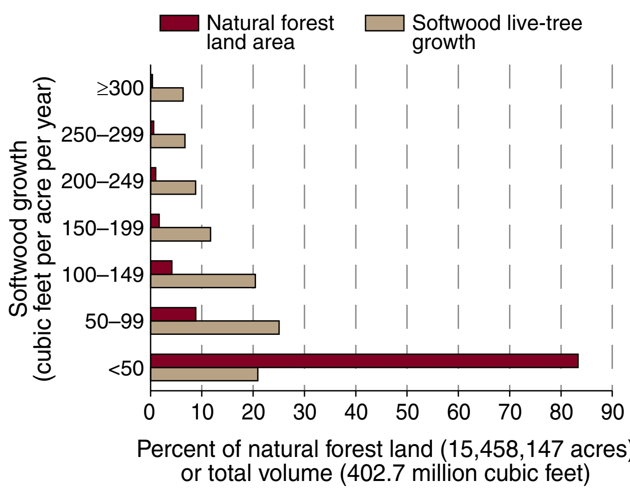


Figure 20—Effective density for live-tree net annual growth for softwoods on forest land by cubic feet per acre class, Arkansas, 2005–10. This figure is based upon land that was in natural stands; i.e., plantations are excluded.

Shortleaf pine shelterwood regeneration on the Ouachita National Forest, Montgomery County, AR.
(photo by James M. Guldin, Southern Research Station)

50 to 99 cubic feet per acre per year. In total, 92 percent of forest land was growing softwood volume at a rate of <100 cubic feet per acre per year. Forty-six percent of softwood growth was in this class. In contrast, very small amounts of forest land were growing at high rates. Approximately 2 percent of forest land was growing at a rate of ≥200 cubic feet per acre per year. More importantly, about 22 percent of Arkansas' softwood growth was in these high yielding stands. This means that 22 percent of softwood growth occurred on 306,400 acres of forest land. The largest proportion of softwood growth (25 percent) was in stands growing at the rate of 50 to 99 cubic feet per acre per year. Small improvements in stand productivity through silvicultural practices (e.g., thinning) would help increase Arkansas' softwood timber inventory and also boost the State's carbon sequestration level.

The effective density analysis for hardwood growth on natural stands was similar to the softwood situation. There were high amounts of forest land with low amounts of growth, and few acres with high growth rates (fig. 21). Seventy-eight percent of natural forest land stands had hardwood growth rates of <50 cubic feet per acre per year. Very few acres were growing hardwoods at high rates (≥200 cubic feet per acre per year), <2 percent of forest land.

A major improvement would be to concentrate efforts toward increasing the growth on forest land that is growing at the rate of <50 cubic feet per acre per year. If stands are understocked, improve stocking; if establishing new stands, make sure stocking (and survival stocking) is adequate. Additionally, regeneration lag times should be kept to a minimum. While these may be lofty goals to increase productivity, it should be recognized that these aggressive practices may also interfere with natural forms of the regeneration/succession cycle. This could impact certain wildlife species and plants that are dependent on the early stage of the succession cycle. Striking a proper balance to achieve resource goals is a challenge for land managers who are also charged with protecting forest ecosystems in their entirety.

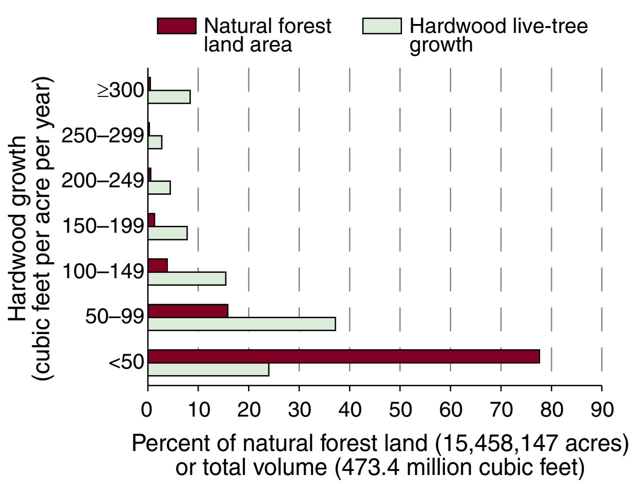


Figure 21—Effective density for live-tree net annual growth for hardwoods on forest land by cubic feet per acre class, Arkansas, 2005–10. This figure is based upon land that was in natural stands; i.e., plantations are excluded.

PLANTATIONS

Plantation Area and Stand Inventory

There were 3.3 million acres of plantation and artificially regenerated stands in Arkansas (table 25). This was approximately 17 percent of all forest land in the State. The Southwest unit had most of these plantations, 2.2 million acres, or 66 percent of all plantations in the State. There were very few pine plantations in the northern and eastern portion of the State, with the majority occurring in the central and southwestern regions (fig. 22). By survey units, the percentage of forest land that was in planted stands ranged from 5 percent in the North Delta to 32 percent in the Southwest unit.

Most of the plantations (>90 percent) were planted in loblolly pine (table 26). Some plantations were planted in shortleaf pine, but as stated previously in the report, loblolly pine has been the favored species in Arkansas. Only 128,900 acres were planted in shortleaf pine (table 26). Another minor component of artificial stands was

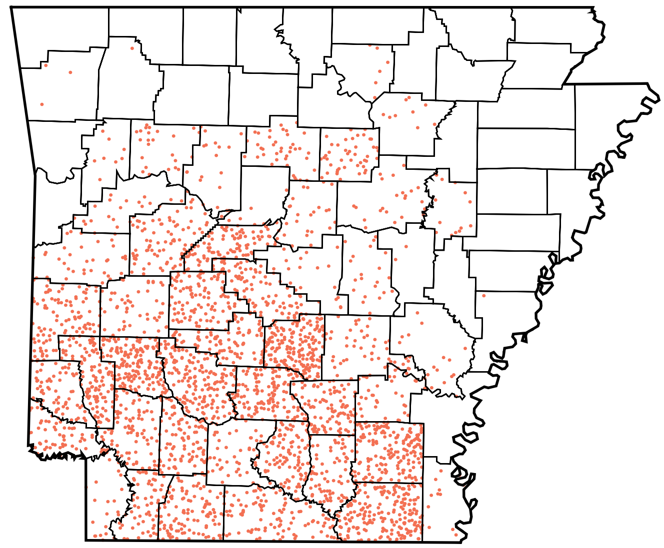


Figure 22—Pine plantation distribution, Arkansas, 2010. Each dot represents 1,000 acres; there were 3,080,900 acres of planted pine across Arkansas. See methods section for map methodology.

Table 25—Forest land area in plantations on forest land by survey unit, year of survey, and change, Arkansas, 2005 and 2010

Survey unit	Year 2005	Year 2010	Change
	thousand acres		
South Delta	117.2	217.5	100.3
North Delta	12.8	40.9	28.1
Southwest	2,005.3	2,163.8	158.5
Ouachita	593.1	595.5	2.5
Ozark	210.4	244.2	33.8
All units	2,938.8	3,262.0	323.2

Numbers in columns may not sum to totals due to rounding.

Table 26—Forest land area in plantations by primary planted species and number of forest conditions, Arkansas, 2010

Primary planted species	FIA species code	Plantation area	Forest conditions
		thousand acres	*number*
Loblolly pine	131	2,952.0	670
Shortleaf pine	110	128.9	30
Nuttall oak	828	74.2	17
Willow oak	831	31.4	7
Green ash	544	20.3	5
Shumard oak	827	12.9	3
Eastern cottonwood	742	11.8	2
Sweetgum	611	10.5	2
Overcup oak	822	6.2	1
Baldcypress	221	4.9	1
Cherrybark oak	813	4.4	1
Black willow	922	3.7	1
Northern red oak	833	0.9	1
Total plantations		3,262.0	741

Numbers in plantation area may not sum to total due to rounding.

in hardwoods, with only 181,200 acres distributed among 11 species (including baldcypress). It was likely that much of the hardwood plantings were done for wildlife management and restoration of abandoned agricultural land. Hardwood plantations were very infrequent across the landscape and usually were established on bottomland sites. In many cases, hardwood plantations are difficult for field crews to recognize because they are seldom in nice, straight, and easily recognized rows (as is the case with softwood plantations). Because it becomes increasingly difficult to recognize hardwood plantations, especially 3+ years after their establishment, the estimate of hardwood plantations should be considered very conservative. There were only 41 sample plot conditions in the survey that had a hardwood species as the primary planted species.

Arkansas forest land had 2.9 billion cubic feet of live-tree softwood volume in plantations (table 27). Most of the plantation volume was in softwoods, and only 250.0 million cubic feet (8 percent) was in hardwoods. With the exception of the hardwood plantings, the hardwood volume was made up of trees that were coincident with softwood plantations. Usually, these were trees that survived stand improvements, thinning operations, or were allowed to grow freely after establishing themselves following plantation establishment. Sixty-five percent of the softwood volume was in the Southwest unit. Southwest Arkansas has some of the most productive sites in the South for loblolly pine, and forest management practices will continue to capitalize on this whether on forest industry- or NIPF-owned lands.

The majority (89 percent) of softwood volume in plantations was in trees <15.0 inches d.b.h. (table 28), while <2 percent was in trees ≥20.0 inches d.b.h. The volume was fairly evenly divided between the 5.0 to 9.9- and 10.0 to 14.9-inch d.b.h. class. Only the Southwest unit had an appreciable amount of volume in trees ≥15.0 inches in d.b.h. This reflects the approach to managing loblolly pine plantations for timber products: rotation lengths are targeted at 25 years or less, and trees are produced to target d.b.h. classes in the 15- to 18-inch diameter range. This production of fast-growth sawtimber has some long-term implications for lumber quality as trees that are grown rapidly tend to have a larger

Table 27—Live-tree volume of softwoods on plantations by survey unit, year of survey, and change, Arkansas, 2005 and 2010

Survey unit	Year 2005	Year 2010	Change
	million cubic feet		
South Delta	111.5	121.8	10.4
North Delta	5.6	17.4	11.8
Southwest	1,766.5	1,872.1	105.6
Ouachita	534.1	599.6	65.5
Ozark	231.4	265.0	33.6
All units	2,649.2	2,875.9	226.7

Numbers in columns may not sum to totals due to rounding.

Table 28—Softwood live-tree volume in plantations on forest land by survey unit and diameter class, Arkansas, 2010

Survey unit	Total volume	Diameter class (*inches at breast height*) 5.0–9.9	10.0–14.9	15.0–19.9	20.0–24.9	25.0–29.9	30.0+
	million cubic feet						
South Delta	121.8	62.2	56.2	3.3	0.0	0.0	0.0
North Delta	17.4	12.0	0.5	4.9	0.0	0.0	0.0
Southwest	1,872.1	866.5	752.4	213.7	34.8	4.8	0.0
Ouachita	599.6	312.0	260.7	26.9	0.0	0.0	0.0
Ozark	265.0	104.0	132.7	26.6	1.7	0.0	0.0
All units	2,875.9	1,356.7	1,202.5	275.4	36.5	4.8	0.0

Numbers in rows and columns may not sum to totals due to rounding.

0.0 = no sample for the cell or a value >0.0 but <0.05.

core of juvenile wood, lower wood density, and less dimensional stability than wood from larger trees grown in naturally regenerated (and perhaps slower growing) stands.

The spatial distribution of softwood volume in plantations was not balanced evenly across forest land in Arkansas. There were large areas with little amounts of softwood volume and smaller amounts of forest land with high volumes (fig. 23). For example, a large proportion of plantation acreage was composed of stands that had <500 cubic feet

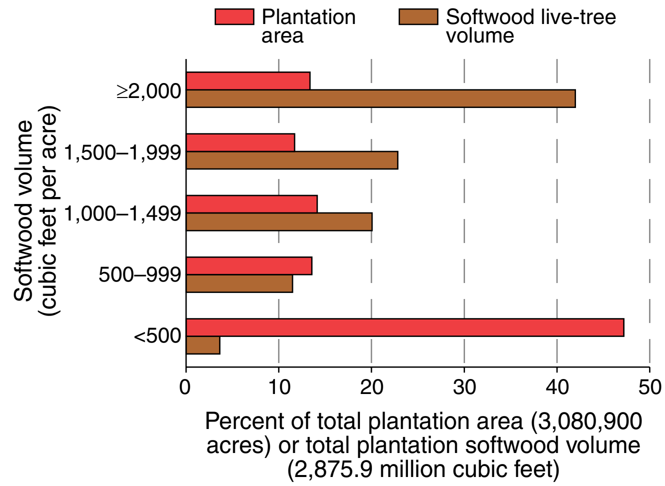


Figure 23—Effective density for live-tree softwood volume in plantations by cubic feet per acre class, Arkansas, 2010. Plantation area, in this instance, is that where softwoods are planted.

Loblolly pine seedlings entering their second growing season in a bedded plantation, Ashley County, AR. (photo by James M. Guldin, Southern Research Station) per acre in softwood live-tree volume. Approximately 47 percent of plantations were in this stand class. These types of plantations accounted for about 4 percent of all plantation softwood volume. In contrast, only 13 percent of plantations were composed of high volume stands, those with ≥2,000 cubic feet per acre per year. Even though these types of stands were not common in extent, approximately 42 percent of plantation softwood volume was located in these stands. Combining the two largest volume classes showed that about 65 percent of softwood volume was on only 25 percent of plantation forest land. Overall, with respect to plantation forestry, there was a large amount of plantation forest land with little volume and a small amount with a large amount of volume.

Plantation Growth, Removals, and Mortality

Plantations were growing softwoods at the rate of 346.2 million cubic feet per year (table 29). This was 46 percent of the total softwood growth in the State. In sharp contrast, hardwoods (on plantations) were growing at the rate of 19.2 million cubic feet per year, 4 percent of Arkansas' hardwood growth. Hardwoods were clearly a very minor component of plantations in the State. Softwood removals, on plantations, were well below growth, averaging 272.7 million cubic feet per year. Fifty percent of Arkansas' softwood removals came from plantations (table 30). This means a larger proportioned share of softwood removals came from plantations because only 17 percent of Arkansas' forest land was in plantations. Softwood plantations carried a major share of the softwood harvest between the 2005 and 2010 surveys. A higher proportion of softwood mortality was on plantations than in natural stands. Twenty-one percent of softwood mortality in Arkansas occurred in plantations, but the expected amount of mortality was not substantially out of balance (compared to the 17 percent proportion of forest land that is in plantations).

The effective density of live-tree softwood net growth shows a pattern slightly different than that of total softwood volume. There was a more even distribution of plantation area by the growth classes, with the exception of the lowest class. Here,

Table 29—Average net annual growth, removals, and mortality of live trees in plantations on forest land by survey unit and by softwoods and hardwoods, Arkansas, 2005–10

	Net growth		Removals		Mortality	
Survey unit	Softwood	Hardwood	Softwood	Hardwood	Softwood	Hardwood
			million cubic feet			
South Delta	15.4	1.6	14.6	2.2	1.2	0.3
North Delta	3.8	0.0	0.1	0.0	0.0	0.0
Southwest	239.9	12.7	208.8	29.8	7.8	1.5
Ouachita	62.0	2.6	35.1	4.7	1.8	0.5
Ozark	25.1	2.3	14.1	1.4	0.9	0.0
All units	346.2	19.2	272.7	38.1	11.7	2.3

Numbers in columns may not sum to totals due to rounding.
0.0 = no sample for the cell or a value >0.0 but <0.05.

Table 30—Comparison of softwood plantation net growth and removals to total softwood net growth and removals, Arkansas, 2005–10

Survey unit	Net growth: Total softwood net growth[a]	Net growth: Total softwood plantation net growth	Removals: Total softwood removals[a]	Removals: Total softwood plantation removals
	million cubic feet			
South Delta	28.9	15.4	22.9	14.6
North Delta	9.6	3.8	2.0	0.1
Southwest	491.5	239.9	404.1	208.8
Ouachita	134.6	62.0	82.4	35.1
Ozark	85.6	25.1	36.7	14.1
All units	750.2	346.2	548.1	272.7

Numbers in columns may not sum to totals due to rounding.
[a] Includes natural stands and plantations.

42 percent of Arkansas' plantations were growing softwoods at the rate of <50 cubic feet per acre per year (fig. 24). Five percent of total plantation softwood growth was in stands of this type, so 42 percent of plantation area contributed little toward the total softwood plantation growth. Approximately 13 percent of Arkansas' plantations were growing softwoods at the annual rate of 50 to 99 cubic feet per acre per year. The highest growth class, plantations growing at the rate of ≥300 cubic feet per acre per year, was present on only 4 percent of plantation forest land. Note that some extremely high growth rates may be present because of small plot proportions resulting from the FIA mapped plot design. These small plot sizes have a direct impact on per-acre estimates. See definition of condition class in the glossary.

Clearly, growth could be improved across Arkansas plantations through better stocking control and a reduction in the lag time between harvest and plantation establishment. However, most of the low acreage situations in the higher growth per acre classes can be attributed to site conditions and the overall young age of plantations in Arkansas, and by different rates of annual growth as plantations go through different stages from planting to harvest.

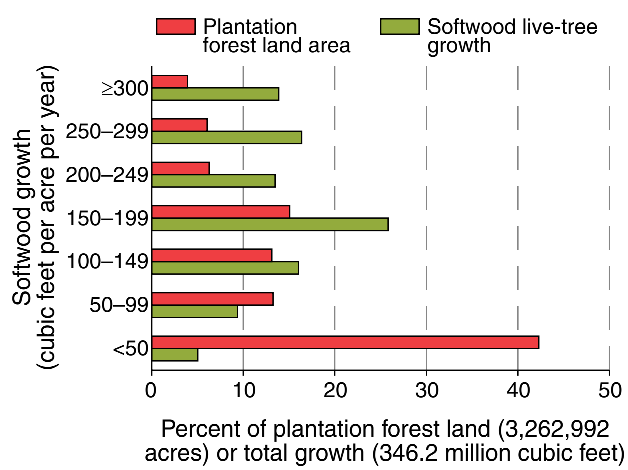
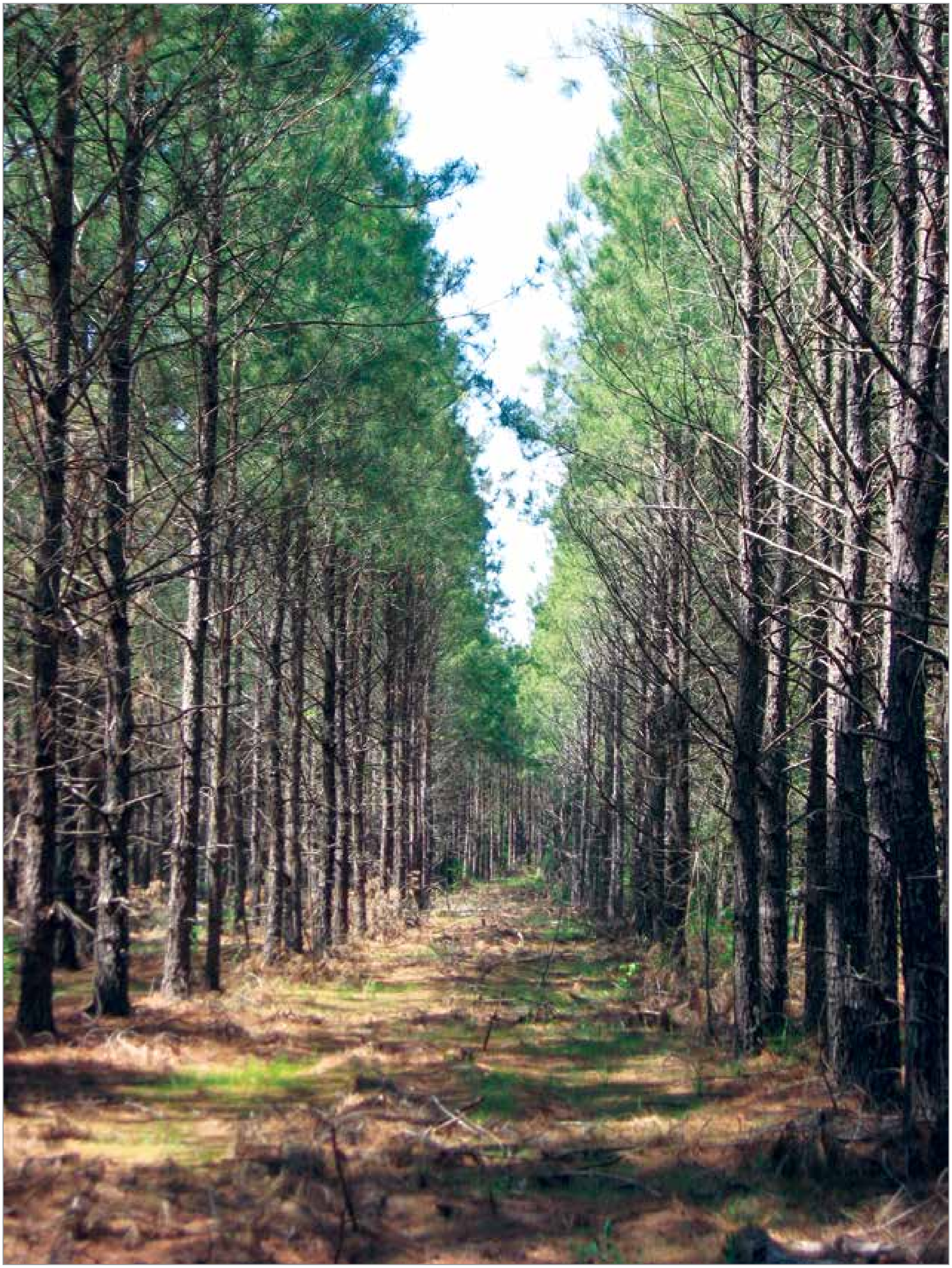


Figure 24—Effective density for live-tree softwood net annual growth by cubic feet per acre class in plantations, Arkansas, 2005–10.



Row thinning in a young loblolly pine plantation, Bradley County, AR.
(photo by James M. Guldin, Southern Research Station)

STAND STRUCTURE

Studying changes in stand structural components can help understand and define the overall health and sustainability levels of Arkansas' forests. Sustainability is a concept that is very difficult to define. In its most simplistic definition, it implies that the portion of the resource considered most important (usually from an economic viewpoint) will last forever; in a more complex form, it means that every biological and abiotic component of a system is considered sustainable for the long term. Somewhere between these two extremes is a working definition that addresses as many important factors as possible. One of the challenges in defining sustainability is identifying resource levels or system thresholds that indicate resource declines or stresses, and at what levels intervention and action should be taken. In all likelihood, the definition of sustainability regarding forest resources will be debated for quite some time. Monitoring resource attributes (such as the components of stand structure) over time is a first step in addressing many sustainability concerns and issues. Many attributes could be studied to assess some degree of sustainability: basal area, stocking, quadratic mean diameter, species diversity, proportions of forest land in old-growth or regeneration stages, etc. Many of these were addressed in the 2005 report (Rosson and Rose 2010). In this report, we focus primarily on the basal area component of forest structure and changes in basal area since the 2005 survey.

Old-growth post oak-dominated forest on steep, rocky, south-facing slope on Fort Chaffee in Sebastian County, AR. Though gnarly and small in stature, the oldest post oaks on this sandstone bluff are between 150 and 200 years old. (photo by Don C. Bragg, Southern Research Station)

Stand Size

The FIA program defines stand size as the size of a stand of trees according to three defined categories: small trees, medium trees, and large trees (see definitions in glossary). Most of Arkansas' forest land (10.4 million acres) was in the large-diameter size class (table 31). The area in this size class was mostly in the Southwest and Ozark units. There were 4.8 million acres in the medium-diameter size stands, with most of that in the Ozark unit followed by the Southwest unit. The least amount of area was in the small-diameter class. There were 3.4 million acres in this size class, and 51 percent was in the Southwest unit. Here, small-diameter stands accounted for 26 percent of the forest land area. In contrast, <2 percent of the forest land area in the Ozark unit was in this smallest diameter class. The high amount of small-sized stands in the Southwest unit can be attributed to high levels of forest management, mostly in the form of plantation establishment.

Stand Basal Area

The basal area of all-live trees (≥1.0 inch d.b.h.) averaged 87.4 square feet per acre across Arkansas' forest land. This was an increase from 86.7 in 2005. The basal area was divided between an average of 30.1 square feet per acre for softwoods and 57.3 square feet per acre for hardwoods. A breakdown by tree size showed 15.0 square feet per acre for trees <5.0 inches in d.b.h. and 72.4 square feet per acre for trees ≥5.0 inches in d.b.h.

Table 31—Area of forest land by survey unit, stand-size class, and change, Arkansas, 2005–10

	Stand-size class							
	Small diameter		Medium diameter		Large diameter		Non-stocked	
Survey unit	2010	Change	2010	Change	2010	Change	2010	Change
	thousand acres							
South Delta	275.8	102.3	207.7	-15.3	874.0	-10.8	31.6	16.1
North Delta	119.3	25.5	163.2	-9.7	477.6	59.9	7.9	6.4
Southwest	1,744.2	80.8	1,494.8	66.8	3,521.5	-68.2	51.0	-20.9
Ouachita	511.1	-2.2	867.7	-82.3	1,992.1	158.4	2.9	-21.5
Ozark	740.4	75.4	2,102.3	-183.3	3,499.6	255.5	35.4	9.9
All units	3,390.8	281.7	4,835.7	-223.7	10,364.9	394.9	128.8	-9.9
Average all-live basal area per acre (*in square feet*)	27.4	-3.2	87.9	0.6	107.7	2.6	3.0	-1.6
Average number of all-live trees per acre	591.7	-70.2	746.1	7.7	541.8	-7.7	28.9	4.2

Numbers in columns may not sum to totals due to rounding.
Average basal area and trees per acre by stand-size class, along with change from 2005, are provided below the main table.

The basal area by stand-size classes showed that basal area decreased in the small-diameter class, was unchanged in the medium class, and increased in the large class (table 31). The number of trees per acre decreased while basal area increased in the large-diameter class. This is an indication that stands are maturing in Arkansas, especially in the larger size classes.

Basal area was also evaluated by individual trees in 2-inch diameter classes. These particular estimates were not done by stand-level evaluations but instead all-live trees were lumped into one aggregated pool and then placed into their respective d.b.h. class. This approach treated the entire State of Arkansas as one giant, unsegregated stand of trees. Figure 25 illustrates how much each diameter class contributed to the total State average basal area of 87.4 square feet per acre. Much of the basal area in Arkansas came from trees in the 6-, 8-, 10-, and 12-inch diameter classes.

Eight arbitrary basal-area classes were established to describe stand structure for the survey units, ownership groups, FTGs, and stand-size classes (tables 32, 33, 34, 35). These basal-area classes represent the stand-level basal area, i.e., the total per acre basal area was compiled for each FIA sample plot. All-live trees (≥1.0 inch d.b.h.) were used to derive this basal area. Most of Arkansas' forest land was in the three basal-area classes ranging from 61 to 120 square feet per acre (table 32). There were 9.6 million acres in these three basal-area classes. This was within the optimum basal area range for normally stocked stands in the Southern United States (Walker 1991). However, it should be noted that the hazard for southern pine beetle outbreaks increases in pine stands that rise above 100 square feet per acre (Guldin 2011).

There were 2.1 million acres of forest land with a basal area ranging from 0 to 20 square feet per acre. Fifty-two percent of

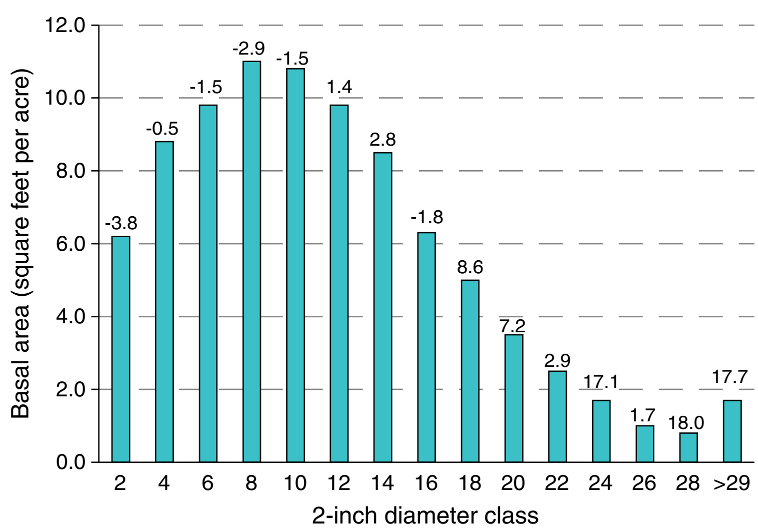


Figure 25—Average per acre basal area of all-live trees on forest land by diameter class, Arkansas, 2010. The numbers above the bars represent the percent change since the 2005 survey. The diameter classes shown represent the midpoints, e.g., the 2-inch class ranges from 1.0–2.9 inches d.b.h., the 4-inch class ranges from 3.0–4.9 inches d.b.h. and so on. The sum of all the basal-area classes equals the average per acre basal area for the 2010 survey, 87.4.

Table 32—Forest land area by survey unit and basal-area class, Arkansas, 2005 and 2010

Survey unit	Basal-area class (*square feet per acre*) >140		121–140		101–120		81–100		61–80		41–60		21–40		0–20	
	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010
	thousand acres															
South Delta	274.1	265.3	126.9	154.8	244.6	219.5	137.6	145.0	194.9	148.7	106.0	139.3	91.1	78.1	121.5	238.4
North Delta	132.3	175.2	79.7	53.9	78.5	115.2	151.0	113.4	93.5	145.2	75.0	51.5	20.8	48.4	55.0	65.2
Southwest	715.3	885.3	801.3	740.2	1,059.2	1,018.4	1,125.4	1,068.7	1,015.4	907.8	594.7	683.9	439.8	437.2	1,001.8	1,070.0
Ouachita	326.9	393.1	326.1	332.8	542.3	543.6	678.6	679.6	615.1	562.2	373.5	364.7	230.2	217.5	228.7	280.3
Ozark	399.5	479.6	558.1	677.4	1,182.1	1,207.8	1,525.8	1,451.6	1,282.0	1,293.7	573.1	563.8	339.5	298.0	360.2	405.7
All units	1,848.1	2,198.5	1,892.0	1,959.0	3,106.8	3,104.5	3,618.4	3,458.3	3,201.0	3,057.7	1,722.3	1,803.2	1,121.3	1,079.2	1,767.2	2,059.7

Numbers in columns may not sum to totals due to rounding.

this forest land was in the Southwest unit (table 32). There were high amounts of acreage in the low basal-area class because of the substantial levels of plantation forestry in this unit and the prevalence of stands too young to have any measurable basal area. In contrast, there were 2.2 million acres with a basal area of >140.0 square feet per acre. The North and South Delta units had the highest proportion of area in this class, 19 and 23 percent, respectively. These higher proportions may reflect longer rotations in bottomland hardwood stands (saw-log products versus pulpwood products), or perhaps a lack of more active aggressive management where stands are left to develop naturally.

Three basal-area classes had decreases in area since the 2005 survey. These were the 21–40, the 61–80, and the 81–100 square-foot classes (table 32). The 101–120 class was basically unchanged. Most of the decline occurred in the important optimum class (61–120), 305,700 acres (88 percent). In contrast, substantial increases occurred in the 0–20 and >140 square-foot classes, 292,500 and 350,400 acres, respectively. It appears that most of the harvesting occurred in the 61–80 and 81–100 square-foot classes, and stand increment from lower classes has not yet filled the niche space. This would also explain some of the increase in the 0–20 square-foot class. Defining the change in acreage throughout the basal-area classes is complicated by the increase of Arkansas' forest land by 442,900 acres since 2005, stand-level increment, and disturbance of existing stands.

The other tables illustrate where these major changes occurred in ownership, FTG, and stand-size classes. A notable shift in public lands was in the highest basal-area class (table 33). Here, there was an increase from 509,900 acres in 2005 to 618,700 acres in 2010, a 108,800-acre increase. This increase indicated a continuation

Table 33—Forest land area by ownership class and basal-area class, Arkansas, 2005 and 2010

Ownership class	Basal-area class (*square feet per acre*)															
	>140		121–140		101–120		81–100		61–80		41–60		21–40		0–20	
	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010
	thousand acres															
Public	509.9	618.7	493.8	452.4	749.5	716.8	744.9	739.1	614.1	639.7	256.5	256.4	116.7	112.6	94.1	127.0
Forest industry	408.1	400.4	379.8	400.4	658.8	487.9	604.8	559.1	645.9	533.5	396.4	375.1	290.0	238.7	755.5	743.8
NIPF	930.1	1,179.4	1,018.4	1,106.3	1,698.5	1,899.8	2,268.7	2,160.1	1,940.9	1,884.5	1,069.4	1,171.6	714.7	727.9	917.6	1,188.9
All classes	1,848.1	2,198.5	1,892.0	1,959.0	3,106.8	3,104.5	3,618.4	3,458.3	3,201.0	3,057.7	1,722.3	1,803.2	1,121.3	1,079.2	1,767.2	2,059.7

Numbers in columns may not sum to totals due to rounding.

0.0 = no sample for the cell or a value >0.0 but <0.05.

NIPF = nonindustrial private forest.

of maturing in those stands on public lands. Other noted changes in this class were on NIPF owned lands, a 27-percent increase. In the smallest basal-area class, most of the acreage was in the NIPF category which also had the largest increase since 2005, 271,300 acres. The decreases in the optimum range of basal-area classes were divided between forest industry and NIPF ownership with the exception of the 101–120 square foot class. Here, NIPF acreage increased by 201,300 acres.

The loblolly-shortleaf pine FTG was fairly stable across all basal-area classes except in the 0–20 square-foot class (table 34). Here, the type increased 200,300 acres, most probably due to the establishment of new plantations. All of the FTGs increased in the >140 basal-area class, but most of the increase was in the bottomland hardwood types where they accounted for 51 percent of the increase, 180,200 acres (141,700 acres in the oak-gum-cypress type, alone). Eighty percent (244,900 acres) of the decrease in the optimum square-foot class (60–120 square foot range) was in the oak-hickory FTG. A likely cause for the decrease was cutting followed by the establishment of plantations.

The change in distribution of acreage across the basal-area classes among the stand-size categories was as expected. There was a large increase (315,300 acres) in the small diameter stands in the 0–20 basal-area class (table 35). Likewise, the large increase in the >140 square foot class was in large diameter stands. The decrease in the optimum class (275,300 acres) was mostly in the medium diameter stand size.

Table 34—Forest land area by forest-type group and basal-area class, Arkansas, 2005 and 2010

	Basal-area class (*square feet per acre*)															
	>140		121–140		101–120		81–100		61–80		41–60		21–40		0–20	
Forest-type group	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010
	thousand acres															
Loblolly-shortleaf	827.9	890.7	690.0	693.3	853.5	814.8	904.5	913.5	788.7	786.0	535.9	533.8	255.6	231.6	430.4	630.7
Eastern redcedar	4.6	22.1	13.0	24.1	34.9	36.6	44.7	44.2	50.1	52.7	35.9	39.7	39.5	55.8	33.2	25.1
Oak-pine	149.2	197.5	242.5	213.0	343.5	364.6	374.8	343.7	369.3	310.7	211.2	213.4	124.3	145.0	217.7	312.7
Oak-hickory	337.3	380.5	601.1	719.4	1,482.6	1,480.8	1,931.2	1,782.8	1,624.4	1,529.7	722.2	742.4	494.5	411.1	723.4	663.9
Oak-gum-cypress	437.7	579.4	257.2	243.8	277.2	309.3	205.6	257.1	265.7	253.1	96.7	129.7	97.7	122.8	101.9	155.8
Elm-ash-cottonwood	89.9	128.4	88.3	65.4	115.0	98.3	156.0	112.5	101.3	118.9	109.7	137.5	102.3	95.9	118.9	135.1
Misc. hardwood	1.5	0.0	0.0	0.0	0.0	0.0	1.5	4.5	1.5	4.9	4.6	6.8	0.0	15.4	10.5	10.6
Nonstocked	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	0.0	7.5	1.6	131.2	125.7
All groups	1,848.1	2,198.5	1,892.0	1,959.0	3,106.8	3,104.5	3,618.4	3,458.3	3,201.0	3,057.7	1,722.3	1,803.2	1,121.3	1,079.2	1,767.2	2,059.7

Numbers in columns may not sum to totals due to rounding.

0.0 = no sample for the cell or a value >0.0 but <0.05.

Table 35—Forest land area by stand-size class and basal-area class, Arkansas, 2005 and 2010

	Basal-area class (*square feet per acre*)															
	>140		121–140		101–120		81–100		61–80		41–60		21–40		0–20	
Stand-size class	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010
	thousand acres															
Small diameter	33.4	25.8	58.4	32.5	97.7	68.9	131.8	149.9	216.7	222.9	309.9	412.5	703.8	605.6	1,557.4	1,872.7
Medium diameter	372.3	367.2	408.5	416.6	726.3	736.0	1,263.3	1,152.5	1,304.8	1,140.3	666.3	731.8	270.3	258.3	47.6	33.1
Large diameter	1,442.4	1,805.5	1,425.1	1,510.0	2,282.8	2,299.6	2,223.3	2,155.9	1,679.5	1,692.9	746.1	658.9	139.8	213.8	31.0	28.2
All classes	1,848.1	2,198.5	1,892.0	1,959.0	3,106.8	3,104.5	3,618.4	3,458.3	3,201.0	3,057.7	1,722.3	1,803.2	1,121.3	1,079.2	1,767.2	2,059.7

Numbers in columns may not sum to totals due to rounding.

Tables 36 and 37 illustrate the strong correlations between volume and basal area. All of the basal area square foot classes showed increases in volume, with the exception of the 81–100, 61–80, and 0–20 square foot classes. Ninety-three percent of the total net volume increase in Arkansas was in the >140 square foot class (table 36). The class with the only substantial loss was the 81–100 square foot class, 274.8 million cubic feet. A similar pattern was evident in sawtimber volume. All of the basal-area classes had increases except for the 81–100 class, which lost 621.8 million board feet. The class with the largest increase was also the >140 square foot class. Here, total sawtimber volume increased 6,889.5 million board feet (table 37). This increase was 80 percent of the net change since the 2005 survey. It appears much of this resulted from growth in older stands and stands growing into this large basal class, as there were 350,400 more acres in this class in 2010 than 2005 (also see table 35).

Species Dominance

One way to broadly assess some aspect of species diversity at the State-level is through some type of dominance measure. One simple approach was used earlier by listing the ranks of individual species according to their respective volumes. A further refinement of this approach is to rank, by species, the amount of forest land a respective species occupies where it is, by some metric, dominant. The arbitrary threshold of dominance applied here was

Looking west over Flatside Wilderness Area to Forked Mountain, Ouachita National Forest, Perry County, AR. Note distribution of pines on south slopes and hardwoods on north slopes in this early spring image. (photo by James M. Guldin, Southern Research Station)

Table 36—Live-tree volume on forest land by survey unit and basal-area class, Arkansas, 2005 and 2010

	Basal-area class (*square feet per acre*)															
	>140		121–140		101–120		81–100		61–80		41–60		21–40		0–20	
Survey unit	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010
	million cubic feet															
South Delta	1,159.5	1,204.4	362.8	435.5	558.3	498.3	244.8	241.4	252.4	180.9	68.6	104.0	28.6	34.6	2.3	11.5
North Delta	531.8	710.7	215.4	150.2	149.6	254.5	238.8	169.2	98.9	150.1	43.5	33.3	6.6	9.8	3.7	2.4
Southwest	2,506.2	3,232.5	1,985.5	1,896.5	2,201.4	2,123.7	1,722.3	1,618.9	1,162.3	1,104.3	459.7	449.6	143.3	168.3	31.4	23.5
Ouachita	963.8	1,265.8	814.9	821.0	1,031.7	1,107.1	1,007.4	988.7	646.5	609.4	245.4	270.6	78.8	81.3	10.9	8.8
Ozark	1,345.9	1,625.4	1,238.4	1,466.5	2,108.6	2,278.0	2,130.4	2,050.6	1,240.1	1,343.3	392.6	378.0	111.5	99.5	25.3	22.4
All units	6,507.3	8,038.8	4,616.9	4,769.7	6,049.6	6,261.5	5,343.6	5,068.8	3,400.2	3,387.9	1,209.8	1,235.4	368.8	393.6	73.7	68.7

Numbers in columns may not sum to totals due to rounding.

Table 37—Sawtimber volume on forest land by survey unit and basal-area class, Arkansas, 2005 and 2010

	Basal-area class (*square feet per acre*)															
	>140		121–140		101–120		81–100		61–80		41–60		21–40		0–20	
Survey unit	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010
	million board feet[a]															
South Delta	4,787.3	5,325.1	1,416.8	1,620.1	2,015.6	1,799.4	739.4	740.5	883.3	549.1	190.0	277.5	28.3	76.8	0.0	16.6
North Delta	2,011.4	2,827.7	763.0	571.2	444.7	893.5	690.3	424.1	235.7	321.6	42.5	42.9	4.9	9.6	1.8	1.7
Southwest	10,175.6	13,200.9	7,392.0	7,013.4	8,381.0	7,997.0	5,975.7	5,425.3	3,989.6	4,128.1	1,533.7	1,377.8	424.1	481.2	32.1	50.1
Ouachita	3,186.0	4,593.9	2,821.6	2,984.5	3,413.2	3,770.0	2,982.7	3,105.8	1,782.6	1,792.5	651.1	769.2	153.5	179.4	9.2	16.3
Ozark	4,683.4	5,785.4	3,360.3	4,202.3	5,346.0	6,317.7	4,740.9	4,811.3	2,438.4	2,836.1	731.7	744.7	141.1	124.0	45.7	33.3
All units	24,843.6	31,733.1	15,753.6	16,391.5	19,600.5	20,777.6	15,128.9	14,507.1	9,329.4	9,627.4	3,149.1	3,212.0	751.9	871.0	88.8	117.9

Numbers in columns may not sum to totals due to rounding.

0.0 = no sample for the cell or a value >0.0 but <0.05.

[a] International ¼-inch rule.

a basal area of ≥50 percent of a plot condition. For this type of evaluation, thresholds other than an arbitrary 50 percent could be used. Theoretically, no matter what dominance threshold is used, the more diverse stands will have species importance (in this case, basal area) distributed among several species. Less diverse forests will have the basal area of the stand confined to fewer species. Important in this type of approach is trend analysis, and monitoring changes in dominance over time will provide some insights into a particular State's overall tree species diversity situation.

Ideally, where species diversity is optimum, there should be very few plots where one species has more than one-half of the importance value (in this instance, the importance value is basal area). There were 62 tree species occupying at least one plot condition with ≥50 percent of basal area in that respective species (table 38). These 62 dominant species were spread across 9.4 million acres of forest land in Arkansas. Loblolly pine was the most dominant species by a wide margin, covering 4.0 million acres, 43 percent of all forest land with dominant species. Shortleaf pine was second with 1.3 million acres. Much of the loblolly pine dominance can be attributed to it being favored so heavily in forest management.

Seventy-eight percent (7.3 million acres) of this class of dominated forest land was dominated by 6 species: loblolly pine, shortleaf pine, post oak, white oak, sweetgum, and eastern redcedar. While some species become dominant through forest management practices (plantations), some become dominant because of their ecological characteristics and habitat adaptation. Examples in Arkansas are post oak capitalizing on harsh growing conditions and eastern redcedar being rapidly and widely distributed by birds. Clearly, plantation establishment and management were responsible for much of the pine-dominant stands in Arkansas. But it should also be noted that early and mid-successional stands are often dominated by one or two species. The large amount of forest land in one-dominant species was also an indicator of past disturbance as stands proceed through the recovery and succession processes.

Softwood/Hardwood Composition

Much of the inventory information is presented by softwood or by hardwood attributes. It is important to consider the amounts of forest land area where these two major species groups coexist in a stand. Figure 26 shows the relative breakdown of forest land stands based upon the relative contribution of softwoods or hardwoods to total stand basal area. The figure only includes upland stands because bottomland hardwoods are usually 100 percent stocked with hardwoods. As an example, there were 2.3 million acres of upland forest land composed of 5 percent stand basal area in hardwoods and 95 percent basal area in softwoods (fig. 26). In contrast, there were 5.5 million acres of forest land with 95 percent of stand basal area in hardwoods and 5 percent in softwoods. The remaining 7.3 million acres were spread between these two extremes. Overall, there were 9.0 million acres of stands with ≥50 percent of basal area in hardwoods and 6.0 million acres with ≥50 percent of basal area in

Table 38—Ranked forest land area by species, where stand basal area[a] is ≥50 percent for a respective species, Arkansas, 2010

Species name	FIA species code	Forest land area	Species name	FIA species code	Forest land area
		thousand acres			*thousand acres*
Loblolly pine	131	3,985.1	Common persimmon	521	21.0
Shortleaf pine	110	1,335.7	Black cherry	762	20.6
Post oak	835	573.9	Boxelder	313	20.5
White oak	802	539.6	Hackberry	462	17.4
Sweetgum	611	467.4	Black locust	901	17.2
Eastern redcedar	68	397.1	Silver maple	317	15.3
Northern red oak	833	152.1	Ashe juniper	61	15.1
Willow oak	831	142.8	Eastern hophornbeam	701	12.7
Southern red oak	812	135.4	Shumard oak	834	11.3
Black oak	837	127.1	Water hickory	401	11.0
Black hickory	408	119.7	Flowering dogwood	491	10.8
Sugarberry	461	118.2	Honeylocust	552	9.2
Overcup oak	822	107.5	American holly	591	8.9
Water oak	827	95.4	Sassafras	931	8.7
Baldcypress	221	92.3	Eastern redbud	471	7.6
Winged elm	971	84.0	Pignut hickory	403	7.5
Green ash	544	74.6	Florida maple	311	7.0
Black willow	922	73.2	Black walnut	602	6.0
Water tupelo	691	55.2	Bitternut hickory	402	4.6
Mockernut hickory	409	49.2	Sweetbay	653	4.5
Cherrybark oak	813	46.4	Osage-orange	641	4.5
Nuttall oak	828	41.3	Paulownia empress-tree	712	4.4
American sycamore	731	39.3	American hornbeam	391	3.4
Red maple	316	38.7	White ash	541	2.6
Pecan	404	38.0	Hawthorn spp.	500	1.9
Blackgum	693	32.6	Ozark chinkapin	423	1.5
American elm	972	24.5	Blue ash	546	1.5
Eastern cottonwood	742	24.5	Other unknown	999	1.5
Water-elm planertree	722	24.4	Yellow-poplar	621	1.5
Blackjack oak	824	22.5	Apple spp.	660	1.1
American beech	531	21.9	River birch	373	0.8
Slippery elm	975	21.3	All species		9,362.4

FIA = Forest Inventory and Analysis.

[a] All-live trees ≥1.0 inch d.b.h. were included in deriving stand basal area per acre.

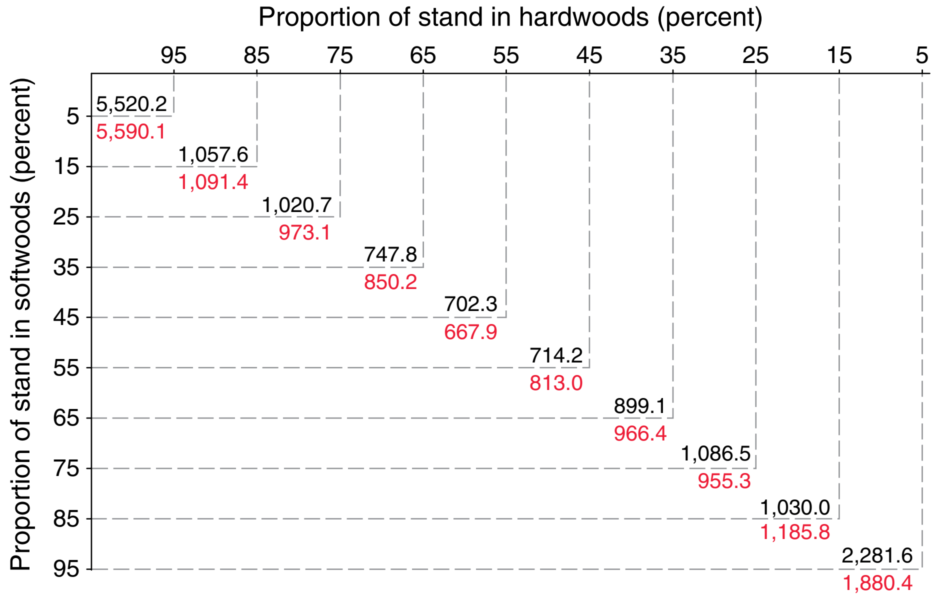


Figure 26—Area of upland forest land by proportion of stand in softwoods and hardwoods, Arkansas, 2005 and 2010. The percentage values are the midpoints of the deciles. Thus, 85 percent includes values ≥80 percent but <90 percent. Area is in thousand acres; the acreage in red is for the 2005 survey. Proportions were based on basal area, and only stands with trees ≥1.0 inch in d.b.h. are included. There were 14,946.6 and 15,060.0 thousand acres included in this graph for the 2005 and 2010 surveys, respectively.

softwoods. Tracking these attributes over time can provide valuable information regarding stand dynamics.

Since the 2005 survey, there has been an increase in pine-dominated stands. The 95-percent softwood class increased from 1.9 to 2.3 million acres, a 401,200 acre increase. The largest increases were in the 95 and 75 percent softwood classes, 401,200 and 131,200 acres, respectively. The largest decreases were in the 85 and 35 percent classes, 155,800 and 102,400 acres, respectively. Overall, six classes decreased and four increased. Again, one of the strong driving forces in these class shifts is the forest management practices favoring loblolly pine in plantation forestry. This influences its share of the available habitat space (also see table 38).

Overall, there has been a slight shift in Arkansas' upland forest structure between the softwood and hardwood components. In 2005, the balance of hardwood- to softwood-dominated stands was 61 to 39 percent (hardwood-dominated stands are defined as stands with ≥50 percent of basal area in hardwoods; softwood-dominated stands are defined as stands with ≥50 percent of basal area in softwoods). By 2010, this has shifted slightly to a 60- to 40-percent balance. Although the shift is small, the favoring of softwoods by forest management practices is a contributing factor to this shift, a shift that may continue into the future.

Loblolly pine, 2nd year hand planted on sheared and bedded site, Ashley County, AR.
(photo by James M. Guldin, Southern Research Station)

DISTURBANCE

Between the 2005 and 2010 surveys, 3.2 million acres underwent some form of cutting (table 39). The cutting was almost evenly divided between forest industry and NIPF ownerships, 1.3 and 1.6 million acres, respectively. There was a difference in the type of cutting done on forest industry lands versus NIPF lands. Most of forest industry lands were clearcut, whereas most of the NIPF lands had a partial-cut harvest (table 39).

There were 1.1 million acres that had a commercial thinning operation since the 2005 survey. In addition, another 232,800 acres had a timber stand improvement operation conducted.

As expected, the majority of cutting and thinning was done in the loblolly-shortleaf pine FTG: 64 percent of the clearcuts and 81 percent of the commercial thinning (table 39).

Most of the stand treatment was centered on site preparation activity (602,500 acres) (table 40). This involved various activities in preparation for planting after removing the managed stand, then planting the selected target plantation species. Much more harvested forest land was put into plantations than allowed to regenerate naturally. In fact, only 262,800 acres of natural regeneration occurred between the 2005 and 2010 surveys.

Table 39—Area of harvesting on forest land by forest-type group and ownership class, Arkansas, 2005–10

Forest-type group and ownership class[a]	Total[b]	Type of cutting: No cutting	Clearcut	Partial cut	Seed tree/ shelterwood	Commercial thinning	TSI	Salvage cut
	thousand acres							
Eastern redcedar								
Public	23.3	23.3	0.0	0.0	0.0	0.0	0.0	0.0
Forest industry	6.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0
NIPF	250.7	233.2	0.0	10.0	0.0	3.0	4.5	0.0
All classes	280.0	262.5	0.0	10.0	0.0	3.0	4.5	0.0
Loblolly-shortleaf pine								
Public	875.2	727.2	11.9	19.5	7.4	70.1	45.1	0.0
Forest industry	2,280.5	1,229.7	438.6	145.7	11.9	419.0	47.4	0.0
NIPF	1,879.3	1,118.2	158.5	155.9	14.9	398.4	39.4	0.0
All classes	5,035.1	3,075.1	609.0	321.2	34.3	887.5	131.9	0.0
Oak-pine								
Public	462.2	445.0	0.0	5.6	0.0	0.0	11.6	0.0
Forest industry	415.7	320.4	57.8	18.0	0.0	19.5	0.0	0.0
NIPF	1,066.9	874.9	49.3	75.4	4.5	47.7	15.0	6.0
All classes	1,944.8	1,640.3	107.0	99.1	4.5	67.2	26.6	6.0
Oak-hickory								
Public	1500.6	1,418.5	3.0	18.1	0.0	17.5	39.0	4.5
Forest industry	663.3	581.0	42.8	19.5	0.0	14.0	6.0	0.0
NIPF	5,168.3	4,694.1	126.3	253.2	8.3	55.7	24.8	6.0
All classes	7,332.2	6,693.6	172.1	290.8	8.3	87.1	69.8	10.5
Bottomland hardwoods[c]								
Public	541.2	523.3	0.0	11.9	0.0	6.0	0.0	0.0
Forest industry	517.0	419.3	25.0	39.5	6.0	27.3	0.0	0.0
NIPF	1,367.2	1,243.0	41.5	62.7	6.2	13.8	0.0	0.0
All classes	2,425.4	2,185.6	66.5	114.1	12.1	47.1	0.0	0.0
Nontyped								
Public	16.6	16.6	0.0	0.0	0.0	0.0	0.0	0.0
Forest industry	30.8	30.8	0.0	0.0	0.0	0.0	0.0	0.0
NIPF	44.9	38.9	0.0	6.0	0.0	0.0	0.0	0.0
All classes	92.3	86.3	0.0	6.0	0.0	0.0	0.0	0.0
All forest-type groups								
Public	3,419.1	3,153.9	14.9	55.2	7.4	93.5	95.7	4.5
Forest industry	3,913.3	2,587.2	564.1	222.8	17.9	479.8	53.4	0.0
NIPF	9,777.3	8,202.4	375.5	563.0	34.0	518.7	83.7	12.1
All classes	17,109.7	13,943.4	954.6	841.0	59.3	1,091.9	232.8	16.5

Numbers in columns may not sum to totals due to rounding.
Number in rows are not additive because the cutting categories are not mutually exclusive.
0.0 = no sample for the cell or a value >0.0 but <0.05.
TSI = timber stand improvement; NIPF = nonindustrial private forest.
[a] Forest-type groups and ownership classes were those from the previous measurement (2005).
[b] Only plots that were forest land at time 1 (2005) and time 2 (2010) and remeasured were included in this table.
[c] Includes the oak-gum-cypress and elm-ash-cottonwood forest-type groups.

Table 40—Area of treatment on forest land by forest-type group and ownership class, Arkansas, 2005–10

Forest-type group and ownership class[a]	Total[b]	Type of treatment					
		No treatment	Cutting	Site preparation	Artificial regeneration	Natural regeneration	Other silvicultural treatment
		thousand acres					
Eastern redcedar							
Public	23.3	23.3	0.0	0.0	0.0	0.0	0.0
Forest industry	6.0	6.0	0.0	0.0	0.0	0.0	0.0
NIPF	250.7	233.2	17.5	0.0	0.0	0.0	0.0
All classes	280.0	262.5	17.5	0.0	0.0	0.0	0.0
Loblolly-shortleaf pine							
Public	875.2	616.3	154.0	16.6	7.6	0.0	109.4
Forest industry	2,280.5	1,148.6	1,062.7	365.5	357.3	57.4	96.7
NIPF	1,879.3	1,066.1	767.2	64.7	74.7	54.4	73.4
All classes	5,035.1	2,831.0	1,983.9	446.7	439.6	111.8	279.5
Oak-pine							
Public	462.2	403.3	17.2	0.0	0.0	0.0	47.3
Forest industry	415.7	296.0	95.3	30.9	50.2	6.3	16.7
NIPF	1,066.9	861.2	198.0	3.0	13.6	15.9	16.6
All classes	1,944.8	1,560.6	310.5	33.9	63.8	22.2	80.5
Oak-hickory							
Public	1,500.6	1,275.2	82.1	0.0	0.0	11.2	155.2
Forest industry	663.3	493.1	82.2	79.8	88.6	11.9	19.3
NIPF	5,168.3	4,612.8	474.3	36.1	48.7	60.0	60.9
All classes	7,332.2	6,381.1	638.6	115.9	137.4	83.1	235.5
Bottomland hardwoods[c]							
Public	541.2	520.5	17.9	0.0	0.0	0.0	8.8
Forest industry	517.0	414.8	97.7	6.0	13.4	22.9	0.0
NIPF	1,367.2	1,231.5	124.1	0.0	11.0	22.8	9.0
All classes	2,425.4	2,166.8	239.8	6.0	24.4	45.8	17.8
Nontyped							
Public	16.6	13.0	0.0	0.0	0.0	0.0	3.5
Forest industry	30.8	21.0	0.0	0.0	9.8	0.0	0.0
NIPF	44.9	33.4	6.0	0.0	5.6	0.0	0.0
All classes	92.3	67.4	6.0	0.0	15.4	0.0	3.5
All forest-type groups							
Public	3,419.1	2,851.6	271.2	16.6	7.6	11.2	324.3
Forest industry	3,913.3	2,379.5	1,338.0	482.1	519.3	98.5	132.7
NIPF	9,777.3	8,038.3	1,587.0	103.8	153.7	153.1	159.9
All classes	17,109.7	13,269.5	3,196.2	602.5	680.5	262.8	617.0

Numbers in columns may not sum to totals due to rounding.
Number in rows are not additive because the treatment categories are not mutually exclusive.
0.0 = no sample for the cell or a value >0.0 but <0.05.
NIPF = nonindustrial private forest.
[a] Forest-type groups and ownership classes were those from the previous measurement (2005).
[b] Only plots that were forest land at time 1 (2005) and time 2 (2010) and remeasured were included in this table.
[c] Includes the oak-gum-cypress and elm-ash-cottonwood forest-type groups.

An overwhelming majority of site preparation took place on forest industry lands (482,100 acres) and in the loblolly-shortleaf pine FTG (365,500 acres). It follows that artificial planting was done on these same acres, 519,300 planted acres on forest industry lands and 357,300 acres in the loblolly-shortleaf pine FTG (table 40).

One particularly interesting item of note was the amounts of other types of silviculture treatment on public lands. Here, 324,300 acres underwent some other form of treatment (table 40). This appeared to be treatments to enhance (or restore) forest stands and communities or manage for wildlife habitat in unique settings. These other treatments may include such activities as use of fertilizers, herbicides, girdling, pruning, invasive species removal or similar activities designed to improve the commercial value of the residual stand, or chaining (a practice used on woodlands to encourage wildlife forage). Prescribed fires are not considered to be a treatment. Note that FIA does not list fire as a treatment because of difficulties differentiating between prescribed and unintended fires. Fire is listed as a disturbance when evidence is encountered.

The information in tables 39 and 40 came from field crew observations. We also quantified cutting and mortality information using sample data by tracking trees over time. These data provided the means to put cutting and mortality in classes based upon the amount of stand basal area removed between the 2005 and 2010 survey. Over 2.9 million acres of Arkansas' forest land had more than 10 percent of stand basal area removed between 2005 and 2010 (table 41). Most of this cutting was in the Southwest unit, 1.8 million acres.

Table 41—Area of forest land by harvest class and survey unit, Arkansas, 2005–10

		Survey unit				
Harvest class[a]	All units	South Delta	North Delta	Southwest	Ouachita	Ozark
percent	- - - - - - - - - - - - - - - - *thousand acres* - - - - - - - - - - - - - - - -					
0–9.9	15,867.3	1,207.4	735.6	4,980.1	2,976.3	5,968.0
10–19.9	469.0	15.0	11.8	276.2	54.7	111.3
20–29.9	403.1	11.6	5.9	225.2	76.2	84.2
30–39.9	454.0	16.6	5.9	329.9	35.8	65.8
40–49.9	313.7	33.8	4.8	185.6	44.1	45.4
50–59.9	227.6	32.7	0.0	121.1	33.5	40.2
60–69.9	196.0	19.9	0.0	113.1	45.4	17.5
70–79.9	161.3	12.1	1.7	123.9	11.5	12.1
80–89.9	226.1	21.5	0.0	159.9	34.8	9.9
≥ 90	402.0	18.5	2.3	296.5	61.4	23.3
All classes	18,720.1	1,389.1	768.0	6,811.5	3,373.9	6,377.7

Numbers in rows and columns may not sum to totals due to rounding.

0.0 = no sample for the cell or a value >0.0 but <0.05.

[a] Percent of total stand basal area removed by cutting.

Heaviest cutting, in terms of basal area removed, was also in the Southwest unit. There were 789,400 acres in Arkansas that had >70 percent of basal area removed. Seventy-four percent of this forest land was in the Southwest unit.

We also looked at the mortality by amounts of basal area lost. Table 42 shows the amount of stand basal area that was lost to mortality between 2005 and 2010. Some stands lost >50 percent (188,500 acres) of basal area to mortality. However, most of the losses were in the 10–19 and 20–29 percent classes, 3.6 and 1.4 million acres, respectively. Most of this level of mortality occurred in the Ozark, Southwest, and Ouachita units. The Ozark unit led in this level of mortality with 2.0 million acres impacted.

Table 42—Area of forest land by mortality class and survey unit, Arkansas, 2005–10

		Survey unit				
Mortality class[a]	All units	South Delta	North Delta	Southwest	Ouachita	Ozark
percent	*thousand acres*					
0–9.9	12,768.7	962.4	525.0	5,090.3	2,040.6	4,150.3
10–19.9	3,580.1	272.5	110.8	1,001.0	766.2	1,429.6
20–29.9	1,446.6	81.7	90.3	431.3	322.2	521.0
30–39.9	545.0	46.1	21.2	156.5	157.3	164.1
40–49.9	191.2	17.3	2.3	60.3	54.2	57.0
50–59.9	62.4	1.2	5.9	38.2	8.6	8.4
60–69.9	33.1	0.0	0.0	6.0	7.5	19.7
70–79.9	45.9	1.3	10.8	6.0	14.1	13.8
80–89.9	23.7	4.9	1.7	6.0	0.0	11.1
≥ 90	23.4	1.6	0.0	16.1	3.1	2.6
All classes	18,720.1	1,389.1	768.0	6,811.5	3,373.9	6,377.7

Numbers in rows and columns may not sum to totals due to rounding.

0.0 = no sample for the cell or a value >0.0 but <0.05.

[a] Percent of total stand basal area lost to mortality.

FOREST HEALTH

Nonnative Invasive Plants

Through competitive exclusion, suppression via allelopathy, and various other methods, nonnative invasive plants (NIP) can suppress tree regeneration and reduce herbaceous species diversity (Merriam and Feil 2002, Orr and others 2005). There is some evidence that past land use and current levels of land development are factors that strongly influence invasion (Lundgren and others 2004). Crews noted NIPs on 49 percent of forested plots (33 percent of forested subplots) (table 43). The Southwest unit had the highest percentage of forested plots with NIPs (61 percent of forested plots), while the South Delta had the lowest (37 percent). Japanese honeysuckle, Chinese privet, and Chinese lespedeza were the most prevalent invasive species in Arkansas's forests (table 44). These three occurred on 38 percent, 12 percent, and 7

Table 43—Number of forested plots and subplots with invasive species present by survey unit, Arkansas, 2010

	Forested plot			Forested subplot		
Survey unit	Total plots	Invasives present		Total subplots	Invasives present	
	- - number - -		*percent*	*- - - number - - -*		*percent*
South Delta	286	106	37.1	1,001	239	23.9
North Delta	149	61	40.9	506	131	25.9
Southwest	1,222	751	61.5	4,665	2,013	43.2
Ouachita	624	328	52.6	2,334	771	33.0
Ozark	1,229	467	38.0	4,378	1,050	24.0
All units	3,510	1,713	48.8	12,884	4,204	32.6

Japanese honeysuckle was the most commonly occurring nonnative invasive species in Arkansas. (photo by Charles T. Bryson, USDA Agricultural Research Service. Bugwood.org)

Table 44—Occurrence of nonnative invasive plants by survey unit, species, plot, and subplot, Arkansas, 2010

Survey unit and species	Forested plots		Forested subplots	
	number	*percent*	*number*	*percent*
Ozark				
Japanese honeysuckle	275	22.4	606	13.8
Chinese privet	112	9.1	193	4.4
Chinese lespedeza	102	8.3	166	3.8
Nonnative roses	90	7.3	124	2.8
Shrubby lespedeza	87	7.1	171	3.9
Tall fescue	51	4.1	106	2.4
Mimosa	12	1.0	14	0.3
Tree-of-heaven	8	0.7	9	0.2
Paulownia	6	0.5	7	0.2
Bush honeysickle	3	0.2	5	0.1
English ivy	2	0.2	2	0.0
Chinaberry	1	0.1	2	0.0
Sacred bamboo	1	0.1	3	0.1
Chinese yams	1	0.1	1	0.0
Periwinkle	1	0.1	1	0.0
Southwest				
Japanese honeysuckle	701	57.4	1837	39.4
Chinese privet	175	14.3	322	6.9
Shrubby lespedeza	57	4.7	82	1.8
Chinese lespedeza	55	4.5	84	1.8
Mimosa	14	1.1	15	0.3
Tall fescue	14	1.1	32	0.7
Nonnative roses	11	0.9	14	0.3
Japanese climbing fern	6	0.5	14	0.3
Bush honeysickle	5	0.4	9	0.2
Chinaberry	4	0.3	5	0.1
Tallowtree	2	0.2	3	0.1
Paulownia	1	0.1	1	0.0
Tree-of-heaven	1	0.1	1	0.0
Japanese privet	1	0.1	1	0.0
Ouachita				
Japanese honeysuckle	205	32.9	474	20.3
Chinese privet	95	15.2	172	7.4
Chinese lespedeza	88	14.1	141	6.0
Shrubby lespedeza	76	12.2	143	6.1
Nonnative roses	26	4.2	35	1.5
Tall fescue	20	3.2	43	1.8
Mimosa	6	1.0	7	0.3
Paulownia	3	0.5	3	0.1
Bush honeysickle	2	0.3	4	0.2
Chinaberry	1	0.2	1	0.0
Sacred bamboo	1	0.2	2	0.1
English ivy	1	0.2	2	0.1
Autumn olive	1	0.2	1	0.0
North Delta				
Japanese honeysuckle	53	35.6	109	21.5
Chinese privet	16	10.7	23	4.5
Nonnative roses	5	3.4	8	1.6
Chinese lespedeza	3	2.0	5	1.0
Mimosa	1	0.7	1	0.2
Tall fescue	1	0.7	3	0.6
Bush honeysickle	1	0.7	3	0.6
Shrubby lespedeza	1	0.7	2	0.4
Cogongrass	1	0.7	4	0.8
South Delta				
Japanese honeysuckle	92	32.2	212	21.2
Chinese privet	39	13.6	65	6.5
Chinese lespedeza	6	2.1	11	1.1
Mimosa	4	1.4	6	0.6
Chinaberry	3	1.0	5	0.5
Nonnative roses	2	0.7	3	0.3
Tall fescue	2	0.7	8	0.8
Kudzu	1	0.3	1	0.1
All units				
Japanese honeysuckle	1326	37.8	3238	25.1
Chinese privet	437	12.5	775	6.0
Chinese lespedeza	254	7.2	407	3.2
Shrubby lespedeza	221	6.3	398	3.1
Nonnative roses	134	3.8	184	1.4
Tall fescue	88	2.5	192	1.5
Mimosa	37	1.1	43	0.3
Bush honeysickle	11	0.3	21	0.2
Paulownia	10	0.3	11	0.1
Tree-of-heaven	9	0.3	10	0.1
Chinaberry	9	0.3	13	0.1
Japanese climbing fern	6	0.2	14	0.1
English ivy	3	0.1	4	0.0
Tallowtree	2	0.1	3	0.0
Sacred bamboo	2	0.1	5	0.0
Autumn olive	1	0.0	1	0.0
Japanese privet	1	0.0	1	0.0
Chinese yams	1	0.0	1	0.0
Kudzu	1	0.0	1	0.0
Periwinkle	1	0.0	1	0.0
Cogongrass	1	0.0	4	0.0

percent of forested plots, respectively. The occurrence of these species was not equal across the State. Japanese honeysuckle occurred most frequently in the Southwest unit (57 percent of plots and 39 percent of subplots) and least frequently in the Ozark unit (22 percent of plots and 14 percent of subplots) (table 44). Cover for most NIPs was <1 percent on over one-third of the subplots they occupied (table 45). Considering only plots where it occurred (2.5 percent of forested plots), cover for tall fescue was >10 percent on 57 percent of the subplots it occurred on. Plots with NIPs had between one (62 percent) and five (0.4 percent) unique species (table 46). Likewise, 76 percent of forested subplots with NIPs had only one unique species.

Forest Health Indicators

In order to address additional factors that affect forest ecosystem health, FIA assesses several forest health indicators. These include ozone-induced injury, crown condition, down woody material, and soil

Table 45—Abundance of nonnative invasive plants on forested subplots, where they occurred by species and cover class, Arkansas, 2010

	Cover class of subplot (*percent*)									
Species	Trace <1		1–10		11–50		51–90		91–100	
	number	*percent*	*number*	*percent*	*number*	*percent*	*number*	*percent*	*number*	*percent*
Japanese honeysuckle	684	21	1,596	49	760	23	177	5	21	1
Chinese privet	272	35	333	43	128	17	37	5	5	1
Chinese lespedeza	156	38	196	48	50	12	5	1	0	0
Shrubby lespedeza	171	43	201	51	25	6	0	0	1	0
Tall fescue	23	12	58	30	66	34	35	18	10	5
Nonnative roses	76	41	92	50	15	8	1	1	0	0
Mimosa	24	56	14	33	5	12	0	0	0	0
Bush honeysuckle	10	48	8	38	2	10	1	5	0	0
Japanese climbing fern	7	50	7	50	0	0	0	0	0	0
Chinaberry	2	15	8	62	3	23	0	0	0	0
Paulownia	2	18	7	64	2	18	0	0	0	0
Tree-of-heaven	4	40	3	30	3	30	0	0	0	0
Sacred bamboo	3	60	2	40	0	0	0	0	0	0
English ivy	1	25	1	25	2	50	0	0	0	0
Cogongrass	0	0	0	0	4	100	0	0	0	0
Tallowtree	3	100	0	0	0	0	0	0	0	0
Japanese privet	1	100	0	0	0	0	0	0	0	0
Autumn olive	0	0	1	100	0	0	0	0	0	0
Kudzu	1	100	0	0	0	0	0	0	0	0
Periwinkle	0	0	0	0	0	0	1	100	0	0
Chinese yams	1	100	0	0	0	0	0	0	0	0

The number column is the number of forested subplots where the species occurred and the percent column is the proportion of all forested subplots where the species occurred.

Table 46—Number of unique nonnative invasive species by survey unit, plot, and subplot, Arkansas, 2010

	Number of unique nonnative invasive species									
	1		2		3		4		5	
Survey unit	Plots	Subplots	Plots	Subplots	Plots	Subplots	Plots	Subplots	Plots	Subplots
	number									
North Delta	41	104	19	27	1	0	0	0	0	—
Ouachita	186	555	98	180	36	31	5	5	3	—
Ozark	265	746	135	255	54	42	10	7	3	—
South Delta	72	177	26	53	7	8	1	1	0	—
Southwest	504	1,634	205	353	36	24	5	2	1	—
All units	1,068	3,216	483	868	134	105	21	15	7	—

— = not possible (only a maximum of four unique species could be tallied on a subplot.

condition. The Phase 3 (P3) indicators are used to establish baselines, estimate biologically relevant thresholds, and detect potential forest health issues that warrant further evaluation. Readers should be aware that these indicators are based on a smaller plot population than the Phase 2 (P2) sample.

Crowns—When trees are under stress, visible changes often take place in the crown. Tree crowns and tree crown health are affected by many biotic and abiotic factors such as tree age, soil conditions, precipitation, air pollution, insects, and disease. Tree age and climatic or site factors, such as drought and soil moisture, are very commonly involved in tree decline (Manion 1981, Mueller-Dombois 1987). Tree senescence and death are a natural part of any forested ecosystem and are often the result of a complex set of factors. The complexity of these factors makes it difficult to determine exact causes. However, monitoring for relatively high levels of negative crown conditions, or changes in crown conditions through time, can indicate areas of concern that may warrant further investigation. Several indicators have been developed to assess crown condition and to detect various states of tree decline. These indicators include crown dieback, foliage transparency, crown density, and sapling crown vigor.

Crown dieback is recorded as percent mortality of the terminal portion of branches that are <1 inch in diameter, and are positioned in the upper portion of the crown (U.S. Department of Agriculture Forest Service 2006). High levels of dieback may indicate the presence of defoliating agents and a general loss of vigor. Increases in crown dieback are an indication of stress, possibly caused by root damage, stem damage that interferes with moisture and nutrient transport to the crown, or direct injury to the crown (Schomaker and others 2007). Crown dieback is considered an indication of recent stress because small dead twigs do not persist for long periods, and because trees typically replace lost twigs and foliage if the stress does not continue.

Across Arkansas, average crown dieback was 1.8 percent. Hardwoods averaged 2.2 percent crown dieback and softwoods averaged 0.2 percent. For the top 15 species tallied on P3 plots, green ash, blackgum, and northern red oak had the highest percentage of trees with >15 percent dieback (table 47).

Foliage transparency is the percentage of skylight that is visible through the live, normally foliated part of the crown (Zarnoch and others 2004). Average foliage transparency for all plots was 24.1 percent. Hardwoods averaged 24 percent foliage transparency and softwoods averaged 25

Table 47—Distribution of species by crown density, crown dieback, and foliage transparency classes, Arkansas, 2010

Species	Total	Crown density (*percent*) 0–25	26–50	≥ 50	Crown dieback (*percent*) <6	6–15	>15	Foliage transparency (*percent*) 0–25	26–50	≥ 50
		number of trees								
Loblolly pine	801	18	603	180	797	2	2	525	273	3
Shortleaf pine	444	14	263	167	440	1	3	293	150	1
White oak	300	4	175	121	279	15	6	273	25	2
Sweetgum	293	12	186	95	280	6	7	239	45	9
Post oak	258	1	182	75	242	13	3	201	56	1
Eastern redcedar	184	7	99	78	180	1	3	102	80	2
Black hickory	167	2	99	66	161	4	2	129	36	2
Black oak	106	1	73	32	85	18	3	80	26	0
Southern red oak	95	1	53	41	89	4	2	65	29	1
Baldcypress	86	5	76	5	86	0	0	5	81	0
Northern red oak	74	1	44	29	70	1	3	59	15	0
Mockernut hickory	65	0	38	27	61	3	1	58	7	0
Green ash	61	7	37	17	46	9	6	44	15	2
Blackgum	60	7	40	13	53	4	3	42	17	1
Winged elm	60	2	44	14	57	2	1	29	31	0

percent. Green ash and sweetgum had the highest percentage of trees with >50 percent transparency (table 47). Over 50 percent of hardwoods had 16 to 25 percent foliage transparency (fig. 27).

Crown density is the percentage of light blocked by branches, foliage, and reproductive structures, relative to the total symmetrical crown outline (Zarnoch and others 2004). Average crown density for all plots was 47 percent. Hardwood averaged 49 percent and softwoods averaged 46 percent crown density. Over one-half of hardwood and softwood trees had 36 to 55 percent crown density (fig. 28). Green ash and blackgum had the highest percentage of trees with crown density <26 percent (table 47).

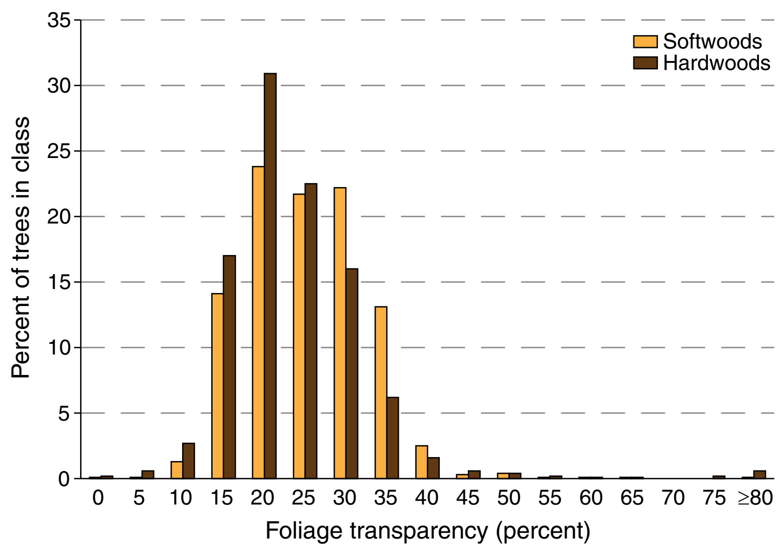


Figure 27—Frequency of foliage transparency by softwoods and hardwoods, Arkansas, 2010.

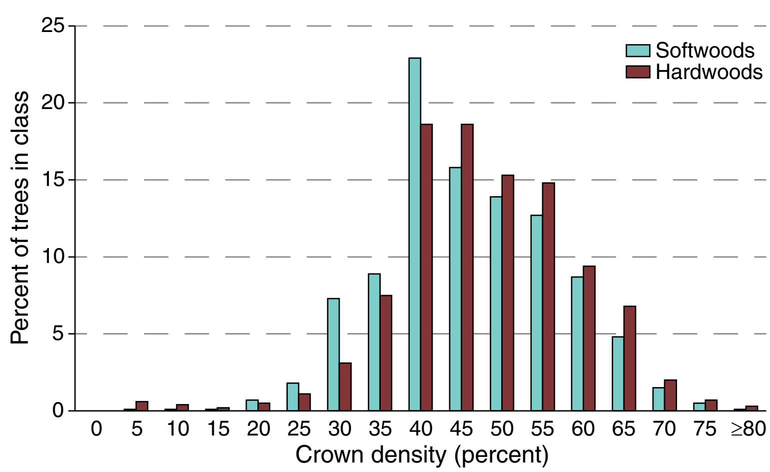


Figure 28—Frequency of crown density by softwoods and hardwoods, Arkansas, 2010. There were no entries above the 80 percent class.

Crown vigor class is used to rate the crown condition of saplings (trees 1.0 to 4.9 inches d.b.h.). Factors that can impact crown vigor in saplings include overhead competition and stand density. Separating natural stand competition functions from insect damage and disease damage is difficult. Overall, 85.2 percent of all saplings were in vigor class 1 (good), 11.8 percent were in vigor class 2 (average), and only 3.1 percent were in vigor class 3 (poor). Among species (those with at least 15 stems tallied), flowering dogwood and sassafras had the lowest percentage of saplings in vigor class 1 (69 and 54 percent, respectively). Sassafras and mockernut hickory had the highest percentage of trees in vigor class 3 (11 percent for both) (table 48).

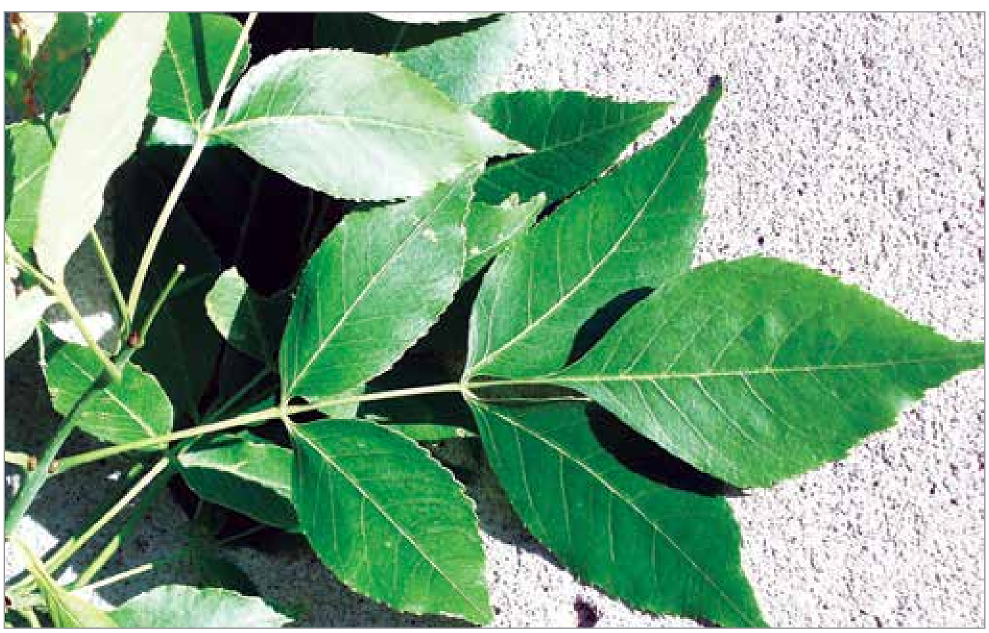
Table 48—Sapling crown vigor class by species, Arkansas, 2010

	Vigor class				Vigor class		
Species	Good	Average	Poor	All trees	Good	Average	Poor
	- - - - - *number of trees* - - - - -				- - *percent of trees* - -		
Loblolly pine	135	16	2	153	88.2	10.5	1.3
Sweetgum	131	16	2	149	87.9	10.7	1.3
Red maple	64	4	2	70	91.4	5.7	2.9
Winged elm	55	12	2	69	79.7	17.4	2.9
Blackgum	51	3	4	58	87.9	5.2	6.9
Flowering dogwood	38	12	5	55	69.1	21.8	9.1
Black hickory	42	7	1	50	84.0	14.0	2.0
Eastern redcedar	43	7	0	50	86.0	14.0	0.0
White oak	36	4	3	43	83.7	9.3	7.0
Shortleaf pine	40	2	0	42	95.2	4.8	0.0
Water oak	29	3	2	34	85.3	8.8	5.9
Southern red oak	28	6	0	34	82.4	17.6	0.0
Eastern hophornbeam	26	4	0	30	86.7	13.3	0.0
Sassafras	15	10	3	28	53.6	35.7	10.7
Mockernut hickory	24	1	3	28	85.7	3.6	10.7
American holly	26	0	0	26	100.0	0.0	0.0
American hornbeam, musclewood	25	0	0	25	100.0	0.0	0.0
Common persimmon	16	4	1	21	76.2	19.0	4.8
Post oak	19	2	0	21	90.5	9.5	0.0
Green ash	20	0	0	20	100.0	0.0	0.0
Black oak	16	3	0	19	84.2	15.8	0.0
Black cherry	13	2	1	16	81.3	12.5	6.3
White ash	10	4	1	15	66.7	26.7	6.7

Ozone—Ozone-induced foliar injury is evaluated between late July and mid-August (U.S. Department of Agriculture Forest Service 2006). The amount and severity of ozone injury varies according to a complex set of factors that include exposure, rates of stomatal uptake, and sensitivity to ozone. Variation in injury within a plant is largely determined by the position of the foliage, exposure to air and sunlight, and the maturity of the leaves. Monitoring foliar injury of bioindicator plants does not identify specific levels of ozone present, but rather identifies whether conditions are favorable for ozone injury to occur (Coulston and others 2003). Although correlations between high levels of ozone exposure and foliar injury have been observed (Smith and others 2003), relationships between ozone exposure and tree responses have been difficult to confirm (Chappelka and Samuelson 1998). Some studies have shown that periods of drought offset the effects of ozone by causing stomatal conductance to be reduced (Patterson and others 2000). During the 2010 survey, 11,252 plants from 24 biosites across Arkansas were evaluated, of which 100 percent showed no ozone injury (table 49).

Table 49—Number of biosites and plants evaluated for ozone-induced foliar injury by year, Arkansas

Year of sample	Biosites evaluated	Plants evaluated	Plants injured
		number	
2006	24	2,160	0
2007	24	2,177	0
2008	24	2,282	0
2009	24	2,191	0
2010	24	2,442	0



Green ash had the highest percentage of trees with >15 percent crown dieback.
(photo by Paul Wray, Iowa State University. Bugwood.org)

Down Woody Material—An important part of any ecosystem is the return of nutrients to the system via decomposition. In forested ecosystems deadwood can be a significant store of nutrients (Harmon and others 1987, Keenan and others 1993). Standing and down-dead trees are also important habitats for a wide variety of organisms, including microbes, invertebrates, fungi, and small mammals. Additionally, a wide range of birds, reptiles, and amphibians depend on deadwood in some part of their lifecycle. Inadequate amounts of coarse woody debris (CWD; down-dead logs ≥3.0 inches in diameter and ≥3.0 feet in length), usually as a result of intensive stand management, can negatively impact small vertebrates in forest ecosystems (Butts and McComb 2000).

Volume of CWD averaged 196.7 cubic feet per acre across the State. This varied from a low of 161.0 cubic feet per acre in the Ouachita unit, to a high of 211.9 cubic feet per acre in the Ozark unit (table 50). While the average (196.7) was an increase of almost 15 percent from 2005 (171.3 cubic feet per acre), many more plots figured into the 2010 average, making a direct comparison difficult. By forest-type group, the oak-pine stands had the highest average volume of CWD (302.5 cubic feet per acre), and, not counting nonstocked stands, loblolly-shortleaf stands had the lowest (180.4 cubic feet per acre) (table 51).

CWD is classified as a 1,000-hour fuel, while fine woody debris (FWD) is classified into 1-, 10-, and 100-hour fuel categories.

Table 50—Coarse and fine woody material volume by survey unit and fuel class, Arkansas, 2010

		Fuel class					
Survey unit	Plots	1-hour [a]	10-hour [a]	100-hour [a]	Fine woody material	1,000-hour [b]	Down woody material
	number	*average cubic feet per acre*					
Delta	30	2.5	30.9	90.4	123.8	206.7	330.5
Southwest	75	3.0	31.1	120.5	154.6	195.0	349.6
Ouachita	37	3.3	26.9	110.5	140.7	161.0	301.7
Ozark	75	3.5	33.2	99.7	136.4	211.9	348.4
All units	217	3.1	31.1	107.5	141.7	196.7	338.4

[a] Pertains to fine woody debris.
[b] Pertains to coarse woody debris.

Table 51—Coarse and fine woody material volume by forest-type group and fuel class, Arkansas, 2010

Forest-type group	Conditions	Fuel class: 1-hour[a]	10-hour[a]	100-hour[a]	Fine woody material	1,000-hour[b]	Down woody material
	number	*average cubic feet per acre*					
Bottomland hardwoods	53	2.9	34.1	97.4	134.3	240.1	374.4
Loblolly-shortleaf	72	3.6	39.7	127.3	170.6	180.4	353.6
Nonstocked	6	1.6	21.9	173.5	197.0	148.2	345.1
Oak-hickory	109	3.8	34.7	112.3	150.8	188.0	340.5
Oak pine	27	3.3	30.7	123.1	157.1	302.5	355.6
All groups	267	3.5	35.2	115.7	154.4	206.8	352.5

[a] Pertains to fine woody debris.
[b] Pertains to coarse woody debris.

These fuel class numbers correspond to the approximate amount of time required for the moisture content to fluctuate within a given piece of deadwood (Brown 1974). Consequently, FWD is an important factor in fire hazard prediction. The 100-hour class FWD, the FWD that dries out slowest and is least hazardous, accounted for the majority of the total FWD biomass (table 52). Overall, FWD biomass averaged 1.9 tons per acre. While plot values ranged from 0 to 13.3 tons per acre, 80 percent of plots had <3.0 tons per acre FWD. Biomass of 1,000-hour fuels averaged 1.8 tons per acre, statewide, with plot values ranging between 0 and 30.6 tons per acre.

Table 52—Coarse and fine woody material mass by survey unit and fuel class, Arkansas, 2010

Survey unit	Plots	Fuel class: 1-hour[a]	10-hour[a]	100-hour[a]	Fine woody material	1,000-hour[b]	Down woody material
	number	*average tons per acre*					
Delta	30	0.0	0.4	1.3	1.7	1.7	3.5
Southwest	75	0.0	0.4	1.6	2.0	1.7	3.8
Ouachita	37	0.0	0.4	1.6	2.0	1.3	3.3
Ozark	75	0.0	0.5	1.4	2.0	2.2	4.2
All units	217	0.0	0.4	1.5	1.9	1.8	3.8

[a] Pertains to fine woody debris.
[b] Pertains to coarse woody debris.

American beautyberry, Ozark National Forest. (photo by James M. Guldin, Southern Research Station)

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The confluence of the Little Buffalo and Buffalo Rivers, Newton County, AR. (photo by James M. Guldin, Southern Research Station)

GLOSSARY

1,000-hour fuels—Coarse woody debris with a transect diameter ≥3.0 inches in diameter and ≥3.0 feet long.

100-hour fuels—Fine woody debris with a transect diameter between 1.0 and 2.9 inches.

10-hour fuels—Fine woody debris with a transect diameter between 0.25 and 0.9 inches.

1-hour fuels—Fine woody debris with a transect diameter <0.25 inches.

Additions—See reversions.

All-live biomass—Weight of trees which includes all trees ≥ 1.0 inches d.b.h. See biomass.

All-live trees—All living trees ≥1.0 inch in d.b.h. All tree sizes, tree classes, and both commercial and noncommercial species are included. Note: live trees includes all living trees ≥5.0 inches in d.b.h. Also, see definitions for live trees, live-tree volume, and all-live biomass.

All-live tree volume—Cubic-foot volume of all living trees ≥1.0 inch in d.b.h. All tree classes, and both commercial and noncommercial species are included. Also, see definitions for live trees, live-tree volume, and all-live biomass.

Average annual mortality—Average annual volume of trees ≥5.0 inches d.b.h. that died during the intersurvey period.

Average annual removals—Average annual volume of trees ≥5.0 inches d.b.h. removed from the inventory by harvesting, cultural operations (such as timber-stand improvement), land clearing, or changes in land use during the intersurvey period.

Average net annual growth—Average annual net change in volume of trees ≥5.0 inches d.b.h. (gross growth minus mortality) during the intersurvey period.

Basal area—The area in square feet of the cross section at breast height of a single tree or of all the trees in a stand, usually expressed in square feet per acre.

Bioindicator species—A tree, woody shrub, or nonwoody herbaceous species that responds to ambient levels of ozone pollution with distinctive visible foliar symptoms.

Biomass—The aboveground oven-dry weight of solid wood and bark in live trees ≥1.0-inch d.b.h., from ground level to the tip of the tree.

Blind check—A reinstallation of a field measurement plot done by a qualified inspection crew without production crew data on hand for the purpose of obtaining a measure of data quality. All plot-level information, and at least two subplots are fully remeasured.

Bole—That portion of a tree between a 1-foot stump and a 4-inch top d.o.b. in trees ≥5.0 inches d.b.h. Also called the merchantable bole or merchantable stem.

Bottomland hardwoods—Stands that have at least 10 percent stocking with oak-gum-cypress or elm-ash-cottonwood forest-type group.

Census water—Streams, sloughs, estuaries, canals, and other moving bodies of water ≥200 feet wide, and lakes, reservoirs, ponds, and other permanent bodies of water ≥4.5 acres in area.

Coarse woody debris (CWD)—Down pieces of wood leaning >45 degrees from vertical with a diameter of at least 3.0 inches and a length of at least 3.0 feet (decay classes 1 through 4). Decay class 5 pieces must be at least 5.0 inches in diameter, at least 5.0 inches high from the ground, and at least 3.0 feet in length.

Cold check—An inspection done either as part of the training process, or as part of the ongoing Quality Control (QC) program. Normally the installation crew is not present at the time of inspection and the inspector has the completed data in-hand at the time of inspection. This type of quality control measurement is a "blind" measurement in that the crews do not know when or which of their plots will be remeasured by the inspection crew and cannot therefore alter their performance because of knowledge that the plot is a QA plot.

Commercial species—Tree species currently or potentially suitable for industrial wood products.

Condition class—The attributes used to subdivide (called mapping) P2 and P3 sample plots that straddle more than one homogeneous condition. This mapping into homogeneous conditions is done in two phases: (1) the first map delineation identifies if forest or nonforest, and (2) if forest, the plot is mapped according to the following condition classes when present: forest type, stand origin, stand size, owner group, reserve status, and stand density.

Crown—The part of a tree or woody plant bearing live branches or foliage.

Crown density—The amount of crown stem, branches, twigs, shoots, buds, foliage, and reproductive structures that block light penetration through the visible crown. Dead branches and dead tops are part of the crown. Live and dead branches below the live crown base are excluded. Broken or missing tops are visually reconstructed when forming this crown outline by comparing outlines of adjacent healthy trees of the same species and d.b.h.

Crown dieback—Recent mortality of branches with fine twigs, which begins at the terminal portion of a branch and proceeds toward the trunk. Dieback is only considered when it occurs in the upper and outer portions of the tree.

Crown-vigor class—A visual assessment of the apparent crown vigor of saplings. The purpose is to separate excellent saplings with superior crowns from stressed individuals with poor crowns.

D.b.h. (diameter at breast height)—Tree diameter in inches (outside bark) at breast height (4.5 feet aboveground).

Decay class—Qualitative assessment of stage of decay (5 classes) of coarse woody debris based on visual assessments of color of wood, presence/absence of twigs and branches, texture of rotten portions, and structural integrity.

Diversions—Land that was forest at the time 1 measurement and changed to nonforest before the time 2 measurement.

D.o.b. (diameter outside bark)—Stem diameter including bark.

Down woody material (DWM)—Woody pieces of trees and shrubs that have been uprooted (no longer supporting growth) or severed from their root system, not self-supporting, and are lying on the ground. Previously named down woody debris (DWD).

Duff—A soil layer dominated by organic material derived from the decomposition of plant and animal litter and deposited on either an organic or a mineral surface. This layer is distinguished from the litter layer in that the original organic material has undergone sufficient decomposition that the source of this material (e.g., individual plant parts) can no longer be identified.

Fine woody debris—Down pieces of wood with a diameter <3.0 inches, not including foliage or bark fragments.

Foliage transparency—The amount of skylight visible through microholes in the live portion of the crown. Recently defoliated branches are included in foliage transparency measurements. Macroholes are excluded unless they are the result of recent defoliation. Dieback and dead branches are always excluded from the estimate. Foliage transparency is different from crown density because it emphasizes foliage and ignores stems, branches, fruits, and holes in the crown.

Forest floor—The entire thickness of organic material overlying the mineral soil, consisting of the litter and the duff (humus).

Forest industry land—See ownership.

Forest land—Land at least 10 percent stocked by forest trees of any size, or formerly having had such tree cover, and not currently developed for nonforest use. The minimum area considered for classification is 1 acre. Forested strips must be at least 120 feet wide.

Forest-type group (FTG)—A grouping of several detailed forest types. The grouping is based on forest types with similar physiographic and physiognomic characteristics.

Eastern redcedar—Forests in which eastern redcedar constitutes a plurality of the stocking. (Common associates in Arkansas, include shortleaf pine, loblolly pine, and oaks.) Note: in national FIA reporting, the eastern redcedar type is included in the pinyon-juniper FTG.

Elm-ash-cottonwood—Forests in which elm, ash, or cottonwood, singly or in combination, constitute a plurality of the stocking. (Common associates include willow, sycamore, beech, and maple.)

Loblolly-shortleaf pine—Forests in which loblolly pine, shortleaf pine, or other southern yellow pines, except longleaf or slash pine, singly or in combination, constitute a plurality of the stocking. (Common associates include oak, hickory, and gum.)

Oak-gum-cypress—Bottomland forests in which tupelo, blackgum, sweetgum, oaks, or southern cypress, singly or in combination, constitute a plurality of the stocking, except where pines account for 25 to 50 percent of stocking, in which case the stand would be classified as oak-pine. (Common associates include cottonwood, willow, ash, elm, hackberry, and maple.)

Oak-hickory—Forests in which upland oaks or hickory, singly or in combination, constitute a plurality of the stocking, except where pines account for 25 to 50 percent, in which case the stand would be classified oak-pine. (Common associates include yellow-poplar, elm, maple, and black walnut.)

Oak-pine—Forests in which hardwoods (usually upland oaks) constitute a plurality of the stocking but in which pines account for 25 to 50 percent of the stocking. (Common associates include gum, hickory, and yellow-poplar.)

Gross annual growth—Annual increase in volume of trees ≥5.0 inches d.b.h (Gross growth includes survivor growth, ingrowth, growth on ingrowth, growth on removals before removal, and growth on mortality before death.)

Growing-stock trees—Living trees of commercial species classified as sawtimber, poletimber, saplings, and seedlings. Trees must contain at least one 12-foot or two 8-foot logs in the saw-log portion, currently or potentially (if too small to qualify), to be classed as growing stock. The log(s) must meet dimension and merchantability standards to qualify. Trees must also have, currently or potentially, one-third of the gross board-foot volume in sound wood.

Growing-stock volume—The cubic-foot volume of sound wood in growing-stock trees at least 5.0 inches d.b.h. from a 1-foot stump to a minimum 4.0-inch top d.o.b. of the central stem.

Growth trees—Classes of trees (from remeasured prism plots) that were used in the growth computations. In the following classes of trees, submerchantable implies <5.0 inches in d.b.h. and merchantable implies ≥5.0 inches in d.b.h.

Ingrowth trees—Submerchantable-and-in at time 1 (previous inventory) and merchantable-and-in at time 2 (current inventory). For this inventory, this is only the trees that were tallied on the 6.8-foot radius fixed plot on points 1, 2, or 3 at time 1 which were ≥1.0 inches d.b.h. but <5.0 inches d.b.h.

Mortality trees—Merchantable-and-in at time 1 and dead prior to time 2.

Removal trees—Merchantable-and-in at time 1 and removed prior to time 2.

Survivor trees—Merchantable-and-in at time 1 and time 2.

Hardwoods—Dicotyledonous trees, usually broadleaf and deciduous.

Soft hardwoods—Hardwood species with an average specific gravity of 0.50 or less, such as gums, yellow-poplar, cottonwoods, red maple, basswoods, and willows.

Hard hardwoods—Hardwood species with an average specific gravity >0.50 such as oaks, hard maples, hickories, and beech.

Hexagonal grid (Hex)—A hexagonal grid formed from equilateral triangles for the purpose of tessellating the FIA inventory sample. Each hexagon in the base grid has an area of 5,937 acres (2402.6 ha) and contains one (phase 2) inventory plot. The base grid can be subdivided into smaller hexagons to intensify the sample.

Humus—A soil layer dominated by organic material derived from the decomposition of plant and animal litter and deposited on either an organic or a mineral surface. This layer is distinguished from the litter layer in that the original organic material has undergone sufficient decomposition that the source of this material (e.g., individual plant parts) can no longer be identified.

Land area—The area of dry land and land temporarily or partly covered by water, such as marshes, swamps, and river floodplains (omitting tidal flats below mean high tide), streams, sloughs, estuaries, and canals <200 feet wide, and lakes, reservoirs, and ponds <4.5 acres in area.

Large-diameter tree—Softwoods ≥9.0 inches d.b.h. and hardwoods ≥11.0 inches d.b.h. These trees were called sawtimber trees in prior surveys. See stand-size class.

Litter—Undercomposed or only partially decomposed organic material that can be readily identified (e.g., plant leaves, twigs, etc.).

Live trees—All living trees ≥5.0 inches in d.b.h. All tree classes, and both commercial and noncommercial species are included. Note: all-live trees includes all living trees ≥1.0 inch in d.b.h. Also, see all-live trees, live-tree volume and all-live biomass.

Live-tree volume—Cubic-foot volume of all living trees ≥5.0 inches in d.b.h. All tree classes, and both commercial and noncommercial species are included.

Measurement quality objective (MQO)—An estimate of the precision, bias, and completeness of data necessary to satisfy a prescribed application (e.g., Resource Planning Act). Describes the established tolerance for each data element. MQOs consist of two parts: a statement of the tolerance and a percentage of time when the collected data are required to be within tolerance. Measurement quality objectives can only be assigned where standard methods of sampling or field measurements exist, or where experience has established upper or lower bounds on precision or bias.

Medium-diameter tree—Softwoods 5.0 to 8.9 inches d.b.h. and hardwoods 5.0 to 10.9 inches d.b.h. These trees were called poletimber trees in prior surveys. See stand-size class.

National forest land—See ownership.

Net annual change—Increase or decrease in stand volume of growing-stock or live trees at least 5.0 inches d.b.h. or larger. Net annual change is equal to net annual growth minus average annual removals.

Net annual growth—Increase in stand volume of growing-stock or live trees 5.0 inches in d.b.h. or larger. Net annual growth is equal to gross growth minus mortality.

Noncensus water—A nonforest classification used by FIA to identify water bodies that are 1 to 4.5 acres, or water courses 30 to 200 feet in width, sizes that are below the thresholds used by the U.S. Census.

Noncommercial species—Tree species of typically small size, poor form, or inferior quality that normally do not develop into trees suitable for industrial wood products.

Nonforest land—Land that has never supported forests and land formerly forested where establishment of trees is precluded by development for other uses.

Nonindustrial private forest (NIPF)—See ownership.

Nonstocked stands—Stands <10 percent stocked with live trees.

Other forest land—Forest land other than timberland and productive reserved forest land. It includes available and reserved forest land which is incapable of producing 20 cubic feet per acre per year of industrial wood under natural conditions, because of adverse site conditions such as sterile soils, dry climate, poor drainage, high elevation, steepness, or rockiness. Called woodland or unproductive forest land in previous reports.

Other public land—See ownership.

Buttercup. (photo by Carey Minteer, University of Arkansas, Bugwood.org)

Ownership—Four classes of ownership were used in this report.

Forest industry land—Land owned by companies or individuals operating primary wood-using plants.

National forest land—Federal land that has been legally designated as national forests or purchase units, and other land under the administration of the Forest Service, including experimental areas and Bankhead-Jones Title III land.

Nonindustrial private forest land—Privately owned land excluding forest industry land.

Other public land—An ownership class that includes all public lands except national forests.

Ozone (O_3)—A regional, gaseous air pollutant produced primarily through sunlight-driven chemical reactions of NO_2 and hydrocarbons in the atmosphere and causing foliar injury to deciduous trees, conifers, shrubs, and herbaceous species.

Ozone bioindicator site (Biosite)—An open area in which ozone injury to ozone-sensitive species is evaluated. The area must meet certain site selection guidelines regarding size, condition, and plant counts to be used for ozone injury evaluations in Forest Inventory and Analysis.

Phase 1 (P1)—Forest Inventory and Analysis activities related to remote-sensing, the primary purpose of which is to label plots and obtain stratum weights for population estimates.

Phase 2 (P2)—Forest Inventory and Analysis activities conducted on the network of ground plots. The primary purpose is to obtain field data that enable classification and summarization of area, tree, and other attributes associated with forest land uses.

Phase 3 (P3)—Forest Inventory and Analysis activities conducted on a subset of Phase 2 plots. Additional attributes related to forest health are measured on phase 3 plots.

Plantation—Stands that currently show evidence of being planted or artificially seeded. See stand origin.

Plot condition—See condition class.

Poletimber-size trees—Softwoods 5.0 to 8.9 inches d.b.h. and hardwoods 5.0 to 10.9 inches d.b.h. Now called medium-diameter tree.

Productive-reserved forest land—Forest land sufficiently productive to qualify as timberland but withdrawn from timber utilization through statute or administrative regulation.

Quality assurance (QA)—The total integrated program for ensuring that the uncertainties inherent in Forest Inventory and Analysis data are known and do not exceed acceptable magnitudes, within a stated level of confidence. Quality assurance encompasses the plans, specifications, and policies affecting the collection, processing, and reporting of data. It is the system of activities designed to provide program managers and project leaders with independent assurance that total system quality control is being effectively implemented.

Quality control (QC)—The routine application of prescribed field and laboratory procedures (e.g., random check cruising, periodic calibration, instrument maintenance, use of certified standards, etc.) in order to reduce random and systematic errors and ensure that data are generated within known and acceptable performance limits. Quality control also ensures the use of qualified personnel; reliable equipment and supplies; training of personnel; good field and laboratory practices; and strict adherence to standard operating procedures.

Reversions—Land that was nonforest at the time 1 measurement and changed to forest before the time 2 measurement. Sometimes called additions.

Rotten trees—Live trees of commercial species not containing at least one 12-foot saw log, or two noncontiguous saw logs, each 8 feet or longer, now or prospectively, primarily because of rot or missing sections, and with less than one-third of the gross board-foot tree volume in sound material.

Rough trees—Live trees of commercial species not containing at least one 12-foot saw log, or two noncontiguous saw logs, each 8 feet or longer, now or prospectively, primarily because of roughness, poor form, splits, and cracks, and with less than one-third of the gross board-foot tree volume in sound material; and live trees of noncommercial species.

Sampling error—The standard error of the mean expressed as a percentage. This percentage format allows the application of confidence intervals to the population values (the most common values presented in FIA reports). Most FIA sampling errors are presented at the 0.6827 level but the 0.95 level can easily be obtained by multiplying the sampling error by 1.96, or higher appropriate t-value if n is <120 (Rohlf and Sokal 1969). In this report, all graphs with confidence interval bars are presented at the 0.95 level of confidence; the sampling errors in tables B.3 and B.4 are presented at the 0.6827 confidence level.

Sapling—Live trees 1.0 to 4.9 inches in diameter. Now called small-diameter tree. See stand-size class.

Saw log—A log meeting minimum standards of diameter, length, and defect, including logs at least 8 feet long, sound and straight, with a minimum diameter inside bark for softwoods of 6 inches (8 inches for hardwoods).

Saw-log portion—The part of the bole of sawtimber trees between a 1-foot stump and the saw-log top.

Sawtimber-size trees—Softwoods ≥9.0 inches d.b.h. and hardwoods ≥11.0 inches d.b.h. Now called large-diameter trees.

Sawtimber volume—Growing-stock volume in the saw-log portion of sawtimber-size trees in board feet (International ¼-inch rule). Includes qualifying softwood trees ≥9.0 inches in d.b.h. and qualifying hardwood trees ≥11.0 inches in d.b.h. See volume of sawtimber.

Seedlings—Trees <1.0 inch d.b.h. and >1 foot tall for hardwoods, >6 inches tall for softwoods, and >0.5 inch in diameter at ground level for longleaf pine. Now called small-diameter tree. See stand-size class.

Select red oaks—A group of several red oak species composed of cherrybark, Shumard, and northern red oaks. Other red oak species are included in the "other red oaks" group.

Select white oaks—A group of several white oak species composed of white, swamp chestnut, swamp white, chinkapin, Durand, and bur oaks. Other white oak species are included in the "other white oaks" group.

Site class—A classification of forest land in terms of potential capacity to grow crops of industrial wood based on fully stocked natural stands.

Small-diameter tree—Trees < 5.0 inches in d.b.h. These trees were called saplings (trees 1.0 to 4.9 inches in d.b.h.) or seedlings (trees < 1.0 inch d.b.h. and > 1-foot tall for hardwoods; > 6 inches tall for softwoods, and > 0.5 inch in d.b.h. at ground level for longleaf pine) in prior surveys. See stand-size class.

Softwoods—Coniferous trees, usually evergreen, having leaves that are needles or scalelike.

Yellow pines—Loblolly, longleaf, slash, pond, shortleaf, pitch, Virginia, sand, spruce, and Table Mountain pines.

Other softwoods—Cypress, eastern redcedar, white-cedar, eastern white pine, eastern hemlock, spruce, and fir.

Stand age—The average age of dominant and codominant trees in the stand.

Stand origin—A classification of forest stands describing their means of origin.

Planted—Planted or artificially seeded.

Natural—No evidence of artificial regeneration.

Stand-size class—A classification of forest land based on the diameter-class distribution of live trees in the stand. See definitions of large tree, medium tree, and small trees.

Large-diameter stands—Stands at least 10 percent stocked with live trees, with one-half or more of total stocking in large and medium trees, and with large-tree stocking at least equal to medium-tree stocking. Called sawtimber in previous reports.

Medium-diameter stands—Stands at least 10 percent stocked with live trees, with one-half or more of total stocking in medium and large trees, and with medium-tree stocking exceeding large-tree stocking. Called poletimber in previous reports.

Small-diameter stands—Stands at least 10 percent stocked with live trees, in which small trees and seedlings account for more than one-half of total stocking. Called sapling-seedling in previous reports.

Nonstocked stands—Stands <10 percent stocked with live trees.

Stocking—The degree of occupancy of land by trees. The stocking value is based on the basal area or the number of trees in a stand as compared to a minimum specified stocking standard.

Stocking standard used by FIA; density of trees and basal area per acre required for full stocking:

D.b.h. class	Trees per acre for full stocking	Basal area
inches		*square feet per acre*
Seedlings	600	—
2	560	—
4	460	—
6	340	67
8	240	84
10	155	85
12	115	90
14	90	96
16	72	101
18	60	106
20	51	111

— = not applicable.

Stocking class—All-live tree stocking classes, including seedlings.

Overstocked—Stands with ≥ 100 percent stocking.

Fully stocked—Stands with 60 to 99 percent stocking.

Medium stocked—Stands with 35 to 59 percent stocking.

Poorly stocked—Stands with 10 to 34 percent stocking.

Nonstocked—Stands with 0 to 9 percent stocking.

Timberland—Forest land capable of producing 20 cubic feet, or more, of industrial wood per acre per year and not withdrawn from timber utilization. Timberland is synonymous with "commercial forest land" in earlier reports.

Tree—Woody plant having one erect perennial stem or trunk at least 3 inches d.b.h., a more or less definitely formed crown of foliage, and a height of at least 13 feet (at maturity).

Tree class—An assessment of the general quality of a tree. Three classes are recognized: growing stock, rough, and rotten. See definitions for these types of trees.

Tree grade—A classification of the saw-log portion of sawtimber trees based on: (1) the grade of the butt log, or (2) the ability to produce at least one 12-foot or two 8-foot logs in the upper section of the saw-log portion. Tree grade is an indicator of quality; grade 1 is the best quality.

Unproductive forest land—See other forest land.

Volume of live trees—The cubic-foot volume of sound wood in live trees at least 5.0 inches d.b.h. from a 1-foot stump to a minimum 4.0-inch bole top d.o.b. of the central stem.

Volume of sawtimber trees (in saw-log portion)—The cubic-foot volume (International ¼-inch rule) of sound wood in the saw-log portion of sawtimber trees (from a 1-foot stump to a log top minimum of 7.0-inches d.o.b. for softwoods; from a 1-foot stump to a log top minimum of 9.0-inches d.o.b. for hardwoods). Volume is the net result after deductions for rot, sweep, and other defects that affect use for lumber. Sawtimber trees are growing-stock trees that meet the minimum size requirements. See definition for growing-stock trees.

Woodland—See other forest land.

INVENTORY METHODS

The current inventory is a 3-phase, fixed-plot design conducted on an annualized basis. Annualized means that a portion of the entire sample population (a cycle) is collected each year (a subcycle) until all of the plots have been measured. For the 2010 survey, measurements were done over a 5-year period (table A.1). Phase 1 (P1) provides the area estimates for the inventory. Phase 2 (P2) involves on the ground measurements of sample plots by field personnel. Phase 3 (P3) is a subset of the P2 plot system where additional measurements are made by field personnel to assess unique forest health indicators, many of which are not measured on the P2 plot.

Table A.1—Change in forest land area by inventory year (a subcycle) throughout the 2010 inventory cycle (cycle 9), Arkansas

Inventory year	Forest land	Change from previous year
	thousand acres	
2005	18,277.2	—[a]
2006	18,376.5	99.3
2007	18,511.3	134.7
2008	18,570.8	59.5
2009	18,681.2	110.4
2010	18,720.1	38.9
Total change[b]		442.9

[a] No change noted; baseline forest land area for inventory year 2005 (cycle 8). Years 2006, 2007, 2008, 2009, and 2010 each carry an additional 20 percent of sampling to the current inventory cycle (cycle 9). Forest land in inventory year 2010 represents the full sample complement of this newest cycle (cycle 9).

[b] Changes may not sum to total due to rounding. Total change is equal to 2010 inventory year (cycle 9) minus the 2005 inventory year (cycle 8) or the addition of changes in the 2006 through 2010 inventory years (subcycles 1, 2, 3, 4, and 5).

The following information is a very brief overview of the Forest Inventory and Analysis (FIA) sample design and some of its features. Further in-depth details about the design may be found in Bechtold and Patterson (2005).

SAMPLE DESIGN OVERVIEW

Sample Design Phases

The three phases (P1, P2, and P3) of the current sampling method are based upon a hexagonal-grid design for sample placement on the ground; successive phases are sampled with less intensity. In general, the P1 phase involves area estimation, the P2 and P3 phases involve placement of sample plots on the ground, where measurement of variable attributes are made. The grid ensures a systematic placement of P2 and P3 plots on the ground. There are 16 P2 hexagons for every P3 hexagon. The P2 and P3 hexagons represent approximately 6,000 acres and 96,000 acres, respectively. To ensure systematic coverage of the sample domain (a State), the goal is to place one P2 plot in every hexagonal grid cell.

Area, P1—The current approach in the determination of forest area applies a stratification technique to improve the precision of the estimate, i.e., it reduces the variance of the estimate. With this method, the placement (on the ground) and subsequent classification (by land use) of the P2 plot carries much of the weight in determining forest area. The area of control was the survey unit. FIA used National Land Cover Data (NLCD) for the stratification platform. The NLCD data has a land classification produced by the U.S. Geological Survey, derived from Landsat Thematic Mapper data. Using this data, FIA identifies four strata to improve the variance. These strata are identified by a pixel classification according to four types of placement: (1) pixels in forest, (2) pixels in nonforest, (3) pixels in nonforest but within a 2-pixel width of a forest edge, and (4) pixels in a forest area but within a 2-pixel width of a forest edge. The estimation of forest area is then the sum across all strata from respective pixel counts (based on placement within the above strata) and the mean area from the P2 plots. This type of approach places more weight on the P2 plot in area determination than with previous aerial-photo dot count methods.

Plot Design

Current P2—Bechtold and Patterson (2005) describe the current P2 and P3 ground plots and explain their use. These plots are clusters of four points arranged so that one point is central and the other three lie 120 feet from it at azimuths of 0, 120, and 240 degrees (fig. A.1). Each point is the center of a circular subplot with a fixed 24-foot radius. Trees ≥5.0 inches in diameter at breast height (d.b.h.) are measured in these subplots. Each subplot in turn contains a circular microplot with a fixed 6.8-foot radius. Trees 1.0 to 4.9 inches in d.b.h. and seedlings (<1.0 inch in d.b.h.) are measured on these microplots (fig. A.2).

Sometimes a plot cluster straddles two or more land use or forest condition classes (Bechtold and Patterson 2005). There are seven condition-class variables that require mapping of a unique condition on a plot: land use, forest type, stand size, ownership, stand density, regeneration status, and reserved status. A new condition is defined and mapped each time the aeral extent of one of these variables is encountered during plot measurement. The process of mapping any of these conditions on a plot changes the plot size for a respective condition, i.e., the condition size will be smaller than a full plot complement and this may increase the variance of the estimate.

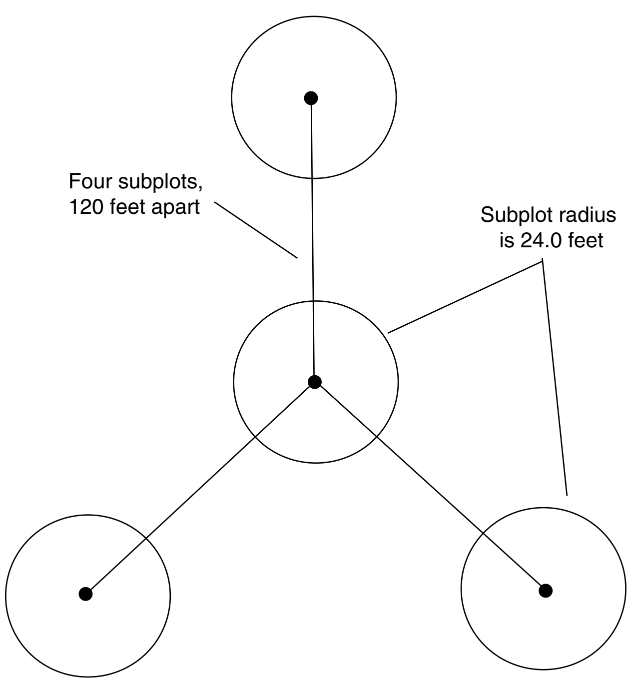

Figure A.1—Annual inventory fixed-plot design (the P2 plot).

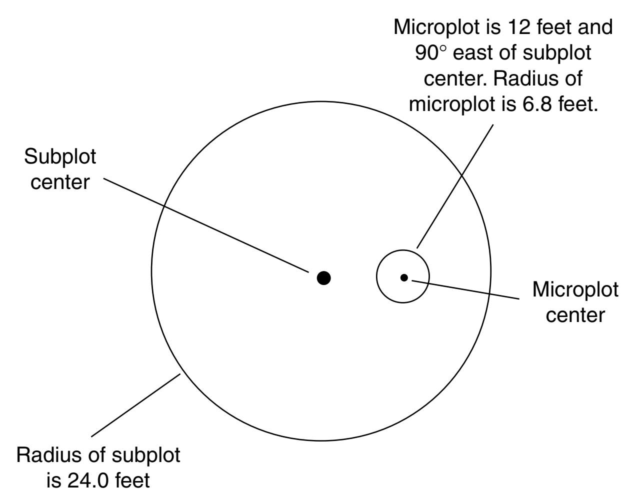

Figure A.2—Subplot and microplot layout.

Current P3—Data on forest health variables (P3) are collected on about 1/16th of the P2 sample plots. P3 data are coarse descriptions, and are meant to be used as general indicators of overall forest health over large geographic areas. P3 data collection includes variables pertaining to tree crown health, down woody material (DWM), foliar ozone injury, lichen diversity, and soil composition. Tree crown health, DWM, and soil composition measurements are collected using the same plot design used during P2 data collection.

Biomonitoring sites for ozone data collection are located independently of the FIA grid. Sites must be 1-acre fields or similar open areas adjacent to or surrounded by forest land, and must contain a minimum number of plants of at least two identified bioindicator species. Plants are evaluated for ozone injury, and voucher specimens are submitted to a regional expert for verification of ozone-induced foliar injury.

Volume Estimation

Current—Tree volumes for each individual tally tree were derived by a linear regression model. The general form of the model involves two tree measurements from sample trees: d.b.h. and total height. This equation estimated gross cubic foot volume from a 1-foot stump to a 4-inch upper diameter for each sample tree. Separate equation coefficients for 77 species or species groupings were utilized. The volume in forks in the central bole and the volume in limbs outside of the main bole were excluded. Net cubic foot volume was derived by subtracting the estimate of rotten or missing wood for each sample tree. Volume of the saw-log portion (expressed in International ¼-inch board feet) of sample trees was derived by using board foot-to-cubic foot ratio equations. All equations and coefficients were developed from standing and felled tree volume studies conducted by FIA across several Southern States. See Southern Research Station (SRS) region in the following document: http://www.fia.fs.fed.us/library/sampling/docs/supplement3_121704.pdf. For more detailed and specific information regarding volume models and coefficients, contact the Southern Research Station, Forest Inventory and Analysis work unit.

Growth, Removals, and Mortality Estimation

Growth, removals, and mortality (GRM) estimates were determined from the remeasurement of 5,469 sample plots measured in the 2005 inventory. Comparisons were not made between the 2010 GRM estimates and those derived from the 2005 survey. This was because the 2005 GRM estimates were derived from variable radius plot sampling (a remeasure of plots originally measured in the 1995 survey).

Trends/Remeasurement Between 2005 and 2010 Surveys

When determining the strength of trend (change between time 1 and time 2 estimates), it is important to consider, not only changes in sample design, but also the number of plots that were remeasured between the survey periods. The sample design for this remeasurement period was essentially the same. However, a 100-percent plot remeasurement was not possible because of strategic issues. Table A.2 shows the plot distribution between the 2005 and 2010 surveys. There were 5,664 and 5,686 plots visited and measured in the 2005 and 2010 surveys, respectively. It appears there was only a difference of 22 plots between the time 1 and time 2 measurements; however, closer examination reveals that only 5,469 plots were actually measured in both surveys. This was because 195 old plots were eliminated and 217 new plots were added

Table A.2—Plot counts by survey year, 2005 and 2010

Attribute	Plots
	number
P2 plots measured in 2005	5,664
P2 plots measured in 2010	5,686
P2 plots measured only in 2005	195
P2 plots measured only in 2010	217
P2 plots measured in both 2005 and 2010 (true remeasure)	5,469

in the 2010 survey, mostly in an effort to ensure that there was one plot properly located in each hexagon of the grid. Other reasons for fluctuations in the remeasured plot numbers were because some plots could not be found (lost plots), access was denied by owners, or hazardous conditions were present (conditions resulting in an unsafe work environment). It is difficult to quantitatively assess how much trend information is impacted from lack of a complete remeasurement, but users should be aware of this issue when evaluating trend information. Estimates highly impacted by lack of plot total remeasurement were growth, removals, and mortality; land use trends; and variables that reflect change because of an activity or disturbance since the previous measurement, e.g., harvesting. The strength of trend analysis is difficult to quantify but increases as plot remeasurement approaches 100 percent between time 1 and time 2.

Dot Map Methodology

Dot maps are a valuable tool to portray the areal distribution of volumetric data. In forestry, these data may be tree volume, tree growth, forest area, etc. They are especially useful in displaying relative densities of resource attributes across State regions.

There are three factors that affect the usefulness and accuracy of dot maps: (1) the size of the dots, (2) the value assigned to each dot, and (3) the placement of the dots on a map (Robinson and others 1984). The choices of values for factors (1) and (2) are mostly arbitrary, but the important function of the maps was to show relative densities of resource attributes across the State of Arkansas.

Regarding factor (3), placement of the dots, the area of control was the county. A minimum volumetric value (cubic-foot volume or area) for a species (or other attribute) was needed in a given county for it to be represented on a map. For example, in order for one dot to be placed in a county representing loblolly pine volume, there had to be a minimum of 1.0 million cubic feet of loblolly pine in that respective county. For two dots, 2.0 million cubic feet were needed and so on. The dots were placed randomly in each county by Geographic Information System software, so that means there was no location accuracy inside any particular county. However, there was adequate accuracy at the regional (survey unit) and State level of scale to portray specific species distributions and relative densities.

Measuring a shortleaf pine on an FIA sample plot, Polk County, AR. (photo by Darren Spinks, Arkansas Forestry Commission)

DATA RELIABILITY

A relative standard of accuracy has been incorporated into the forest survey. This standard satisfies user demands, minimizes human and instrumental sources of error, and keeps costs within prescribed limits. The two primary types of error are measurement error and sampling error.

Measurement Error

Measurement error is also called nonsampling or data acquisition error. These are errors that arise in the acquisition, recording, or editing of statistical data (Burt and Barber 1996). There are three elements of measurement error: (1) biased error, caused by instruments not properly calibrated; (2) compensating error, caused by instruments of moderate precision; and (3) accidental error, caused by human error in measuring, recording, and compiling. All of these are held to a minimum by a system—the Forest Inventory and Analysis (FIA) quality assurance (QA) program—that incorporates training, check plots, and editing and checking for consistency. The goal of the QA program is to provide a framework to assure the production of complete, accurate, and unbiased forest assessments for given standards.

One of the objectives of the FIA program is to include data quality documentation in all nationally available reports including State reports and national summary reports. The following is a summary of some of the P2 variables and measurement quality objective (MQO) analyses from FIA blind check measurements.

It is not possible to determine measurement error statistically, but it is held to a minimum level through a number of quality control (QC) procedures. These methods include use of nationally standardized field manuals, use of portable data recorders (PDRs), thorough entry-level training, periodic review training, supervision, use of check plots, editing checks, and an emphasis on careful work. Additionally, data quality is assessed and documented using performance measurements and post survey assessments. These assessments are then used to identify areas of the data collection process that need improvement or refinement in order to meet quality objectives of the program.

Editing checks in the PDR and office screen out logical and data entry inconsistencies and errors for all plots. Use of PDR's also helps ensure that specified procedures are followed. The minimum national standards for annual training of field crews are: (1) a minimum of 40 hours for new employees, and (2) a minimum of 8 hours for returning employees. Field crew members are certified on a test plot. All crews are required to have at least one certified person present on the plot at all times.

Field audits consist of hot checks, cold checks, and blind checks. A hot check is an inspection normally done as part of the training process. The inspector is present with the crew to document crew performance as plots are measured. The recommended intensity for hot checks is 2 percent of the plots installed.

Cold checks are done at regular intervals throughout the field season. The crew that installed the plot is not present at the time of inspection and does not know when or which plots will be remeasured. The inspector visits the completed plot, evaluates the crew's data collection, and notes corrections where necessary. The recommended intensity for cold checks is 5 percent of the plots installed.

A blind check is a complete reinstallation measurement of a previously completed plot. However, the QA crew performs the remeasurement without the previously recorded data. This type of blind measurement provides a direct, unbiased observation of measurement precision from two independent crews. Plots selected for blind checks are chosen to be a representative subsample of all plots measured and are randomly selected. Blind checks are planned to take place within 2 weeks of the date of the field measurement. The recommended intensity for blind checks is 3 percent of the plots installed.

Each variable collected by FIA is assigned an MQO and a measurement tolerance level. The MQOs are documented in the FIA National Field Manuals for P3 and P2 data collection (U.S. Department of Agriculture Forest Service 2007, U.S. Department of Agriculture Forest Service 2010). In some instances the MQOs are a "best guess" of what experienced field crews should be able to consistently achieve. Tolerances are somewhat arbitrary and are based on the ability of crews to make repeatable measurements or observations within the assigned MQO. Based on review and analysis, these tolerances improved over time.

Evaluation of field crew performance is accomplished by calculating the differences between data collected by the field crew and that collected by the QA crew on blind check plots. Results of these calculations are compared to the established MQOs. In the analysis of blind-check data, an observation is within tolerance when the difference between the field crew observation and the QA crew observation does not exceed the assigned tolerance for that variable. For many categorical variables, the tolerance is "no error" allowed, so only observations that are identical with the standard are within the tolerance level. Tables B.1 and B.2 show the percentage of observations that were within the program tolerances for plot-level and tree-level conditions, respectively. At this time, only the blind-check results for plot-level and tree-level variables are presented.

Table B.1—Blind-check results for some select plot-level variables for Arkansas and the Southern Region

		Percent within tolerance		Number of observations	
Variable	Tolerance	Arkansas	Southern Region	Arkansas	Southern Region
		- - - - - *percent* - - - - -		- - - - - *number* - - - - -	
National variables					
Distance to road	No tolerance	70.6	72.5	34	426
Water on plot	No tolerance	88.2	85.4	34	426
Latitude	±140 feet	100.0	100.0	39	494
Longitude	±140 feet	100.0	100.0	39	494
Elevation	No tolerance	22.9	44.6	35	464
Elevation with tolerance	±5 feet	22.9	40.7	35	464
Regional variables[a]					
Distance to agriculture	No tolerance	85.7	70.1	7	174
Distance to urban area	No tolerance	57.1	61.5	7	174
Accessibility	No tolerance	92.3	86.2	13	247
Number of conditions	No tolerance	23.1	59.5	13	247
Plots in correct county	No tolerance	100.0	99.6	13	247

[a] Variables either not collected at national level or have tolerances that are stricter.

Source: David Gartner, Mathematical Statistician, Southern Research Station, U.S. Forest Service.

Table B.2—Blind-check results for some select tree-level variables for Arkansas and the Southern Region

Variable	Tolerance	Percent within tolerance		Number of observations	
		Arkansas	Southern Region	Arkansas	Southern Region
		- - - - - *percent* - - - - -		- - - - - *number* - - - - -	
National variables					
Condition number	No tolerance	100.0	100.0	877	4,314
D.b.h.	±0.1/20 inch	91.8	84.7	697	3,729
Azimuth	±10 degrees	99.3	99.8	741	4,041
Horizontal distance	±0.2/1.0 feet	98.0	95.1	741	4,041
Species	No tolerance	98.4	94.9	877	4,314
Genus	No tolerance	99.7	98.8	877	4,314
Tree status	No tolerance	99.4	98.7	877	4,314
Reconcile	No tolerance	100.0	97.1	135	646
Total length	±10 percent	88.5	64.4	676	3,628
Actual length	±10 percent	90.9	58.9	22	163
Compacted crown ratio	±10 percent	88.1	79.0	708	3,861
Crown class	No tolerance	88.4	82.3	708	3,861
Decay class	±1 class	97.8	96.9	45	293
Standing dead	No tolerance	99.2	99.7	119	610
Cause of death	No tolerance	98.0	95.1	203	670
Mortality year	±1 year	93.1	96.0	203	670
Regional variables[a]					
Azimuth	±3 degrees	94.3	90.0	741	4,035
Tree class	No tolerance	93.9	90.2	628	3,698
Tree grade	No tolerance	78.1	70.1	160	652
Utilization class	No tolerance	99.1	99.4	452	3,232
Board foot cull	±10 percent	97.7	97.2	560	3,423
Cubic foot cull	±10 percent	97.8	97.6	370	3,188
Fusiform rust/dieback incidence	No tolerance	98.0	98.5	98	2,973
Fusiform rust/dieback severity	No tolerance	97.6	99.3	371	3,188

D.b.h. = diameter at breast height.
[a] Variables either not collected at the national level or have tolerances that are stricter.
Source: David Gartner, Mathematical Statistician, Southern Research Station, U.S. Forest Service.

Sampling Error

Sampling error is associated with the natural and expected deviation of the sample from the true population mean (see the Glossary for definition of sampling error). This deviation is susceptible to a mathematical evaluation of the probability of error. Sampling errors for State totals are based on one standard deviation unless otherwise noted; that is, there is a 68.27 percent probability that the confidence interval given for each sample estimate will cover the true population mean (table B.3).

The sampling error for area is derived by the binary formula. The sampling error for tree-measured assessments (volume, biomass, growth, removals, mortality) is derived by the random sampling formula. The sampling errors for the tree-measured assessments did not include the area error. In addition, these volume and biomass estimates were derived by models and the model error was not included in the sampling error.

The size of the sampling error generally increases as the size of the area examined decreases. Also, as area or volume totals are stratified by forest type, species, diameter class, ownership, or other subunits, the sampling error may increase and be greatest for the smallest divisions. However, there may be instances where a smaller component does not have a proportionately larger sampling error. This can happen when the post-defined strata are more homogeneous than the larger strata, thereby resulting in a smaller variance.

Table B.3—Sampling errors, at one standard error, for estimates of total forest land area[a] (2010), volume[b], average net annual growth[b] (2005–10), average annual removals[b] (2005–10), and average annual mortality[b] (2005–10), Arkansas

Component	Component total	Percent sampling error
Forest land area (*thousand acres*)	18,720.1	0.63
Total live trees[c]		
Volume	29,224.4	1.42
Average net annual growth	1,242.2	2.18
Average annual removals	858.6	4.82
Average annual mortality	227.3	4.53
Total sawtimber[d]		
Volume	97,237.7	2.00
Average net annual growth	5,069.0	2.42
Average annual removals	3,190.6	5.78
Average annual mortality	566.7	7.58
Softwood live trees[c]		
Volume	11,218.1	2.32
Average net annual growth	750.2	2.85
Average annual removals	548.1	5.47
Average annual mortality	56.8	8.38
Softwood sawtimber[d e]		
Volume	45,871.0	2.80
Average net annual growth	3,219.6	3.11
Average annual removals	2,269.6	6.34
Average annual mortality	178.5	11.62
Hardwood live trees[c]		
Volume	18,006.3	1.88
Average net annual growth	492.1	3.30
Average annual removals	310.5	7.76
Average annual mortality	170.5	5.35
Hardwood sawtimber[d e]		
Volume	51,366.7	2.63
Average net annual growth	1849.4	3.83
Average annual removals	921.0	11.11
Average annual mortality	388.3	9.71

Note that the component totals are for plots that were in a forest land status at the end of the 2005 measurement period and remeasured in the 2010 measurement period.

Numbers in columns may not sum to totals due to rounding.

[a] By binomial formula.

[b] By random sampling formula.

[c] Million cubic feet.

[d] Million board feet.

[e] International ¼-inch rule.

The magnitude of the increase (where homogeneity is not changed over that of the normal State-level sample) is depicted in table B.4. For specific post-defined strata, the sampling error can be calculated using the following formula:

$$SE_s = SE_t \frac{\sqrt{X_t}}{\sqrt{X_s}}$$

where

SE_s = sampling error for subdivision of survey unit or State total

SE_t = sampling error for survey unit or State total

X_s = sum of values for the variable of interest (area or volume) for subdivision of survey unit or State

X_t = total area or volume for survey unit or State

For example, the estimate of the sampling error for softwood live-tree growth on forest industry forest land (table 16) is computed as:

$$SE_s = 2.85 \frac{\sqrt{750.2}}{\sqrt{330.9}} = 4.29$$

Thus, the sampling error is 4.29 percent, and the resulting 68.27 percent confidence interval for softwood live-tree growth on forest industry forest land is 330.9 ± 14.2 million cubic feet.

Sampling errors obtained by this method are only approximations of reliability because this process assumes constant variance across all subdivisions of totals. Therefore, resulting errors derived by this approximation method should be considered very liberal, i.e., it usually produces sampling errors much better than those derived by the actual random sampling formula.

Table B.4—Sampling error approximations to which estimates are liable at one standard error, Arkansas, 2010[a]

Sampling error	Forest land area	Volume	Average net annual growth	Average annual removals	Average annual mortality	Volume	Average net annual growth	Average annual removals	Average annual mortality
percent	*thousand acres*	- - - - - - - - - - *million cubic feet*			- - - - - - - - - -	- - - - - - - - - *million board feet*[b]			- - - - - - - - - -
1.0	6,516.5								
2.0	1,629.1	14,732.0				97,237.7			
3.0	724.1	6,547.6	655.9			43,216.8	3,298.5		
4.0	407.3	3,683.0	369.0			24,309.4	1,855.4		
5.0	260.7	2,357.1	236.1	797.9	187.4	15,558.0	1,187.4		
10.0	65.2	589.3	59.0	199.5	46.9	3,889.5	296.9	1,059.6	325.6
15.0	29.0	261.9	26.2	88.7	20.8	1,728.7	131.9	470.9	144.7
20.0	16.3	147.3	14.8	49.9	11.7	972.4	74.2	264.9	81.4
25.0	10.4	94.3	9.5	31.9	7.5	622.3	47.5	169.5	52.1

[a] Component estimates for a given sampling error are derived by ratio approximation.
[b] International ¼-inch rule.

Two-month old cottonwood sprouting from planted rootstock on land that has been site prepped by shearing and bedding, Nevada County, AR. (photo by Teddy Reynolds, Reynolds Forestry Consulting and Real Estate)

Table C.1—Common name, scientific name, and FIA species codes of tree species ≥1.0 but <5.0 inches in d.b.h. occurring in the FIA sample, Arkansas, 2010

Common name	Scientific name	FIA species code	Trees tallied in sample
			number
Ashe juniper	*Juniperus ashei*	61	21
Eastern redcedar	*J. virginiana*	68	992
Shortleaf pine	*Pinus echinata*	110	581
Loblolly pine	*P. taeda*	131	2,281
Baldcypress	*Taxodium distichum*	221	16
Florida maple	*Acer barbatum*	311	135
Boxelder	*A. negundo*	313	67
Red maple	*A. rubrum*	316	1,093
Silver maple	*A. saccharinum*	317	7
Sugar maple	*A. saccharum*	318	15
Ailanthus	*Ailanthus altissima*	341	7
Mimosa, silktree	*Albizia julibrissin*	345	12
Serviceberry spp.	*Amelanchier* spp.	356	102
Pawpaw	*Asimina triloba*	367	48
River birch	*Betula nigra*	373	10
Gum bumelia	*Bumelia* spp.	381	9
American hornbeam	*Carpinus caroliniana*	391	603
Water hickory	*Carya aquatica*	401	26
Bitternut hickory	*C. cordiformis*	402	49
Pignut hickory	*C. glabra*	403	17
Pecan	*C. illinoensis*	404	15
Shellbark hickory	*C. laciniosa*	405	1
Nutmeg hickory	*C. myristiciformis*	406	1
Shagbark hickory	*C. ovata*	407	85
Black hickory	*C. texana*	408	788
Mockernut hickory	*C. tomentosa*	409	564
Ozark chinkapin	*Castanea ozarkensis*	423	8
Sugarberry	*Celtis laevigata*	461	149
Hackberry	*C. occidentalis*	462	66
Eastern redbud	*Cercis canadensis*	471	143
Flowering dogwood	*Cornus florida*	491	859
Hawthorn spp.	*Crataegus* spp.	500	33
Cockspur hawthorn	*C. crus-galli*	501	1
Downy hawthorn	*C. mollis*	502	1
Common persimmon	*Diospyros virginiana*	521	266
American beech	*Fagus grandifolia*	531	37
White ash	*Fraxinus americana*	541	145
Green ash	*F. pennsylvanica*	544	401
Blue ash	*F. quadrangulata*	546	6
Honeylocust	*Gleditsia triacanthos*	552	38
American holly	*Ilex opaca*	591	366
Black walnut	*Juglans nigra*	602	7

continued

Table C.1—Common name, scientific name, and FIA species codes of tree species ≥1.0 but <5.0 inches in d.b.h. occurring in the FIA sample, Arkansas, 2010 (continued)

Common name	Scientific name	FIA species code	Trees tallied in sample
			number
Sweetgum	*Liquidambar styraciflua*	611	1,959
Yellow-poplar	*Liriodendron tulipifera*	621	13
Osage-orange	*Maclura pomifera*	641	6
Cucumbertree	*Magnolia acuminata*	651	1
Sweetbay	*M. virginiana*	653	40
Umbrella magnolia	*M. tripetala*	658	8
Red mulberry	*Morus rubra*	682	26
Water tupelo	*Nyssa aquatica*	691	19
Blackgum	*N. sylvatica*	693	849
Eastern hophornbeam	*Ostrya virginiana*	701	832
Paulownia	*Paulownia tomentosa*	712	4
Water-elm, planertree	*Planera aquatica*	722	86
American sycamore	*Platanus occidentalis*	731	30
Eastern cottonwood	*Populus deltoides*	742	2
Cherry and plum spp.	*Prunus* spp.	760	3
Black cherry	*P. serotina*	762	331
American plum	*P. americana*	766	21
White oak	*Quercus alba*	802	747
Southern red oak	*Q. falcata*	812	404
Cherrybark oak	*Q. falcata* var. *pagodifolia*	813	146
Shingle oak	*Q. imbricaria*	817	2
Laurel oak	*Q. laurifolia*	820	4
Overcup oak	*Q. lyrata*	822	39
Blackjack oak	*Q. marilandica*	824	139
Swamp chestnut oak	*Q. michauxii*	825	25
Chinkapin oak	*Q. muehlenbergii*	826	44
Water oak	*Q. nigra*	827	409
Nuttall oak	*Q. nuttallii*	828	26
Willow oak	*Q. phellos*	831	224
Northern red oak	*Q. rubra*	833	156
Shumard oak	*Q. shumardii*	834	10
Post oak	*Q. stellata*	835	497
Black oak	*Q. velutina*	837	265
Black locust	*Robinia pseudoacacia*	901	50
Black willow	*Salix nigra*	922	26
Sassafras	*Sassafras albidum*	931	221
American basswood	*Tilia americana*	951	8
Winged elm	*Ulmus alata*	971	1,444
American elm	*U. americana*	972	119
Cedar elm	*U. crassifolia*	973	8
Slippery elm	*U. rubra*	975	108

D.b.h. = diameter at breast height; FIA = Forest Inventory and Analysis.
There were 19,422 trees tallied in this size class. Nomenclature follows Little (1979).

Table C.2—Common name, scientific name, and FIA species codes of tree species ≥5.0 inches in d.b.h. occurring in the FIA sample, Arkansas, 2010

Common name	Scientific name	FIA species code	Trees tallied in sample
			number
Ashe juniper	*Juniperus ashei*	61	127
Eastern redcedar	*J. virginiana*	68	2,917
Shortleaf pine	*Pinus echinata*	110	6,996
Loblolly pine	*P. taeda*	131	16,977
Baldcypress	*Taxodium distichum*	221	351
Florida maple	*Acer barbatum*	311	355
Boxelder	*A. negundo*	313	245
Red maple	*A. rubrum*	316	1,279
Silver maple	*A. saccharinum*	317	86
Sugar maple	*A. saccharum*	318	65
Ailanthus	*Ailanthus altissima*	341	5
Mimosa, silktree	*Albizia julibrissin*	345	6
Serviceberry spp.	*Amelanchier* spp.	356	56
Pawpaw	*Asimina triloba*	367	3
River birch	*Betula nigra*	373	55
Gum bumelia	*Bumelia* spp.	381	9
American hornbeam	*Carpinus caroliniana*	391	439
Water hickory	*Carya aquatica*	401	221
Bitternut hickory	*C. cordiformis*	402	292
Pignut hickory	*C. glabra*	403	149
Pecan	*C. illinoensis*	404	105
Shellbark hickory	*C. laciniosa*	405	8
Nutmeg hickory	*C. myristiciformis*	406	6
Shagbark hickory	*C. ovata*	407	388
Black hickory	*C. texana*	408	3,043
Mockernut hickory	*C. tomentosa*	409	1,845
Ozark chinkapin	*Castanea ozarkensis*	423	3
Southern catalpa	*Catalpa bignonioides*	451	1
Northern catalpa	*C. speciosa*	452	5
Sugarberry	*Celtis laevigata*	461	822
Hackberry	*C. occidentalis*	462	167
Eastern redbud	*Cercis canadensis*	471	76
Flowering dogwood	*Cornus florida*	491	208
Hawthorn spp.	*Crataegus* spp.	500	3
Common persimmon	*Diospyros virginiana*	521	256
American beech	*Fagus grandifolia*	531	162
White ash	*Fraxinus americana*	541	382
Green ash	*F. pennsylvanica*	544	946
Blue ash	*F. quadrangulata*	546	10
Carolina ash	*F. caroliniana*	548	2

continued

Table C.2—Common name, scientific name, and FIA species codes of tree species ≥5.0 inches in d.b.h. occurring in the FIA sample, Arkansas, 2010 (continued)

Common name	Scientific name	FIA species code	Trees tallied in sample
			number
Waterlocust	*Gleditsia aquatica*	551	50
Honeylocust	*G. triacanthos*	552	140
Kentucky coffeetree	*Gymnocladus dioicus*	571	2
Carolina silverbell	*Halesia carolina*	581	1
American holly	*Ilex opaca*	591	291
Butternut	*Juglans cinerea*	601	7
Black walnut	*J. nigra*	602	179
Sweetgum	*Liquidambar styraciflua*	611	4,808
Yellow-poplar	*Liriodendron tulipifera*	621	27
Osage-orange	*Maclura pomifera*	641	62
Cucumbertree	*Magnolia acuminata*	651	7
Southern magnolia	*M. grandiflora*	652	1
Sweetbay	*M. virginiana*	653	62
Umbrella magnolia	*M. tripetala*	658	20
Apple spp.	*Malus* spp.	660	3
Southern crab apple	*M. angustifolia*	662	1
Chinaberry	*Melia azedarach*	993	9
White mulberry	*Morus alba*	681	1
Red mulberry	*M. rubra*	682	71
Water tupelo	*Nyssa aquatica*	691	395
Blackgum	*N. sylvatica*	693	1,534
Swamp tupelo	*N. biflora*	694	7
Eastern hophornbeam	*Ostrya virginiana*	701	244
Paulownia, empress-tree	*Paulownia tomentosa*	712	4
Water-elm, planertree	*Planera aquatica*	722	279
American sycamore	*Platanus occidentalis*	731	223
Eastern cottonwood	*Populus deltoides*	742	41
Black cherry	*Prunus serotina*	762	576
American plum	*P. americana*	766	4
White oak	*Quercus alba*	802	5,826
Southern red oak	*Q. falcata*	812	1,426
Cherrybark oak	*Q. falcata* var. *pagodifolia*	813	650
Shingle oak	*Q. imbricaria*	817	4
Laurel oak	*Q. laurifolia*	820	14
Overcup oak	*Q. lyrata*	822	507
Bur oak	*Q. macrocarpa*	823	6
Blackjack oak	*Q. marilandica*	824	500
Swamp chestnut oak	*Q. michauxii*	825	121
Chinkapin oak	*Q. muehlenbergii*	826	288
Water oak	*Q. nigra*	827	1,015

continued

Table C.2—Common name, scientific name, and FIA species codes of tree species ≥5.0 inches in d.b.h. occurring in the FIA sample, Arkansas, 2010 (continued)

Common name	Scientific name	FIA species code	Trees tallied in sample
			number
Nuttall oak	*Quercus nuttallii*	828	233
Willow oak	*Q. phellos*	831	736
Northern red oak	*Q. rubra*	833	1,859
Shumard oak	*Q. shumardii*	834	84
Post oak	*Q. stellata*	835	4,426
Delta post oak	*Q. stellata* var. *mississippiensis*	836	10
Black oak	*Q. velutina*	837	1,904
Bluejack oak	*Q. incana*	842	1
Black locust	*Robinia pseudoacacia*	901	113
Black willow	*Salix nigra*	922	274
Sassafras	*Sassafras albidum*	931	183
American basswood	*Tilia americana*	951	59
Winged elm	*Ulmus alata*	971	1,439
American elm	*U. americana*	972	447
Cedar elm	*U. crassifolia*	973	73
Slippery elm	*U. rubra*	975	421
Unknown hardwood		998	1

D.b.h. = diameter at breast height; FIA = Forest Inventory and Analysis.

There were 70,740 trees tallied in this size class. Nomenclature follows Little (1979).

Rosson, James F., Jr.; Rose, Anita K. 2015. Arkansas' forests, 2010. Resour. Bull. SRS–203. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 100 p.

The principal findings of the ninth forest survey of Arkansas are presented. The survey examines trends between the 2005 and 2010 surveys. Topics examined include forest area, ownership, forest-type groups, stand structure, basal area, timber volume, growth, removals, mortality, crown characteristics, ozone levels, and invasive species.

Keywords: FIA, forest disturbance, forest harvest, forest inventory, forest plantations, forest productivity, forest survey, species distribution, species dominance, trend analysis.

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The Buffalo River in Newton County, AR. (photo by James M. Guldin, Southern Research Station)

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