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General Technical
Report SRS-35

Ozark-Ouachita Highlands Assessment

Terrestrial Vegetation and Wildlife

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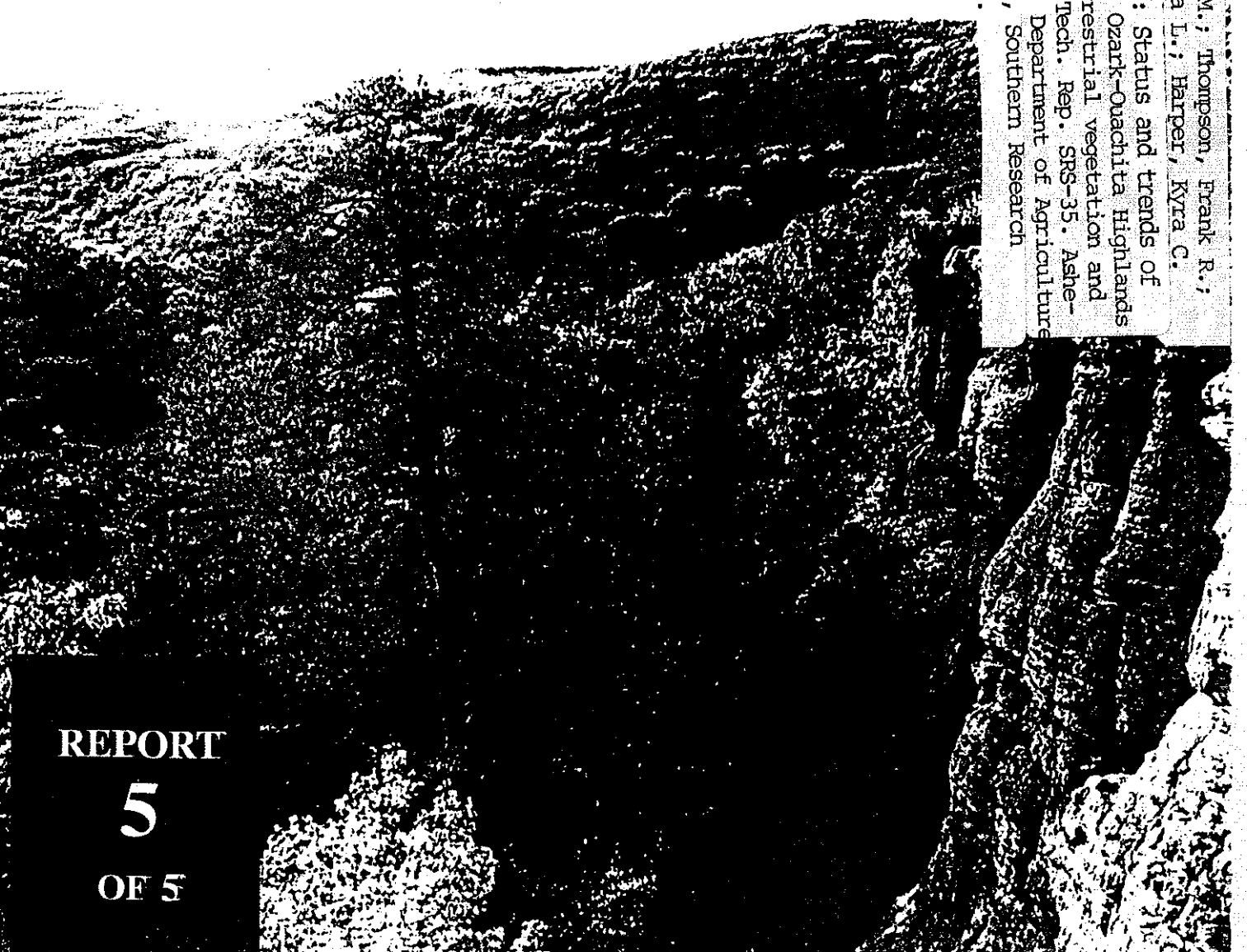

REPORT
5
OF 5

Cover photo: Kings Bluff in the Ozark Mountains of Arkansas.

Photo by A.C. Haralson, Arkansas Department of Parks and Recreation, Little Rock, AR.

Natural resource specialists and research scientists worked together to produce the five General Technical Reports that comprise the *Ozark-Ouachita Highlands Assessment*:

- Summary Report
- Air Quality
- Aquatic Conditions
- Social and Economic Conditions
- Terrestrial Vegetation and Wildlife

For information regarding how to obtain these Assessment documents, please contact: USDA Forest Service, P.O. Box 1270, Hot Springs, AR 71902 or telephone 501-321-5202.

To limit publication costs, few color maps and figures were used in the Assessment reports. For color versions of some of the Assessment figures and supplemental material, please see the Assessment's home page on the Internet at **<http://www.fs.fed.us/oonf/ooha/welcome.htm>**. The Assessment reports will be online for about 2 years after the date on this publication; then they will be archived.

Please note: When "authors" are agency or business names, most are abbreviated to save space in the citations of the body of the report. The "References" at the end of the report contain both the full name and abbreviations. Because abbreviations sometimes are not in the same alphabetical order as the references, for clarifications of abbreviations, consult the "Glossary of Abbreviations and Acronyms."

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Ozark-Ouachita Highlands Assessment:

Terrestrial Vegetation and Wildlife

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Chapter 3: Status and Trends of Vegetation

Question 3.1: What trends in vegetation cover and land use have occurred over the past 50 years?

Question 3.2: Are changes in vegetation cover—including age-class distribution, species composition (e.g., cover types), and fragmentation—taking place?

Question 3.3: How are old-growth forest stands distributed? What is their management status? What is the potential for retention or restoration of such communities?

This chapter provides information about the vegetation cover of the Assessment area. The types and areal extent of vegetation in the Highlands are of interest for many reasons. Vegetation cover largely determines the availability of habitat for terrestrial animals, plants, and other organisms. Vegetation cover strongly influences what uses (e.g., timber, forage, recreation) people can make of natural biological resources. Vegetation cover plays a major role in maintaining desired riparian and aquatic conditions (see USDA FS 1999a). Many people care (for aesthetic and other personal, largely noneconomic reasons) about the extent and types of vegetation cover in the Highlands and the changes it may be undergoing. Finally, information about vegetation cover enhances the ability of scientists to study the availability of plant and animal habitats over large areas and gives all interested parties a clearer picture of the changing representation of various cover types (e.g., conifer-dominated vs. hardwood-dominated forest or forests vs. pasture land) over time.

Key Findings

1. As measured by Advanced Very High-Resolution Radiometer data, oak-hickory forest is the most extensive vegetation type in the Assessment area, covering 15 million acres (ac) or 36 percent of the area.
2. Oak-pine forest is the second most extensive vegetation type within the region, with 4.4 million ac (11 percent of the Assessment area). The largest acreage of this type (660,000 ac) occurs within the Fourche Mountains subsection of the Ouachita Mountains.
3. Nonindustrial private forest (NIPF) owners hold 68 percent of the 22.89 million ac of timberland in the Assessment area; forest industry owns 11 percent. Thus, private and corporate landowners together hold more than 79 percent of the timberland. The remaining 21 percent consists of public timberlands, three-fourths of which are within one of the national forests.
4. The abundance of oak in the Ozark-Ouachita Highlands is matched by only two other regions in the United States, the Central Appalachian and Eastern Broadleaf Forest (Continental) Provinces.
5. The annual net growth of hardwoods and softwoods is more than double the annual removals.
6. Since the 1970's, forested area has increased in five of the six Forest Inventory and Analysis (FIA) survey regions in the Highlands and, in some instances, dramatically.

Vegetation Cover

A Comparison of the Highlands to Surrounding Ecoregions

Processes and patterns at local, landscape, and regional scales influence the distribution of species and local biological diversity, thus making assessments at each of those scales important. The following sections compare the composition and patterns of land cover in the Ozark-Ouachita Highlands to land cover in surrounding ecological provinces and to the Eastern United States.

Data Sources and Methods of Analysis

This analysis was conducted at the province level of the National Hierarchical Framework of Ecological Units (McNab and Avers 1994). The Assessment area includes parts of two ecological provinces, the Southeastern Mixed Forest (map units 231and M231 in Keys and others 1995) and Eastern Broadleaf Forest (Continental) Provinces (units 222 and M222 in Keys and others 1995). The Team compared land cover of the Assessment area to the remaining parts of provinces 222 and 231 and to provinces M221, 221, 232, 234, 251, and 255 (fig. 3.1). The Team also compared the land cover of the Assessment area to that of the Humid Temperate Domain, which essentially corresponds to the Eastern United States.

The Team used land cover units mapped by the U.S. Department of Agriculture, Forest Service, from Advanced Very High Resolution Radiometer (AVHRR) data. Land cover types include 13 forest types, a nonforest class, and an aquatic class. The classes are mapped as 1-kilometer-square pixels. These data provide a large scale but coarse-grained assessment of land cover (fig. 3.2).

Because of the large scale and large pixel size, this report includes only a few landscape statistics, including the percentage of each land cover, the percentage of coverage in all forest types combined, the mean forest patch size, and the total area. Percent forest cover and mean-patch size are useful statistics for a coarse-grained assessment of forest fragmentation (Robinson and others 1995). When the percentage of forest cover and mean patch sizes are relatively low, the forest is more fragmented than when the percentage of forest cover and mean patch size are high.

Patterns and Trends

Oak-hickory, oak-pine, and loblolly-shortleaf pine forests cover large portions of the Assessment area (fig. 3.2 and table 3.1). Compared to other parts of the Eastern United States, the Assessment area has the third highest proportions of these forest types. Because of its geographic location and the dominance of these three forest types, the Assessment area has fewer forest types than provinces that include more northern types (white-red-jack pine, spruce-fir, maple-beech-birch, aspen-birch) or southeastern forest types (longleaf-slash pine).

Notable differences exist in land cover between the Assessment area and surrounding provinces. The Assessment area is in the mid-range of values for percentage of forest cover and mean forest patch size in the provinces and above these values for the Eastern United States (table 3.1).

Implications and Opportunities

The prominence of oak in the Highlands is matched by only two other provinces in the United States, marking it as an especially significant forest resource. The high percentage of forest cover and the large mean forest patch size indicate low levels of forest fragmentation. As a result, the area is of high value to wildlife species that are sensitive to fragmentation of forest cover by nonforest land uses.

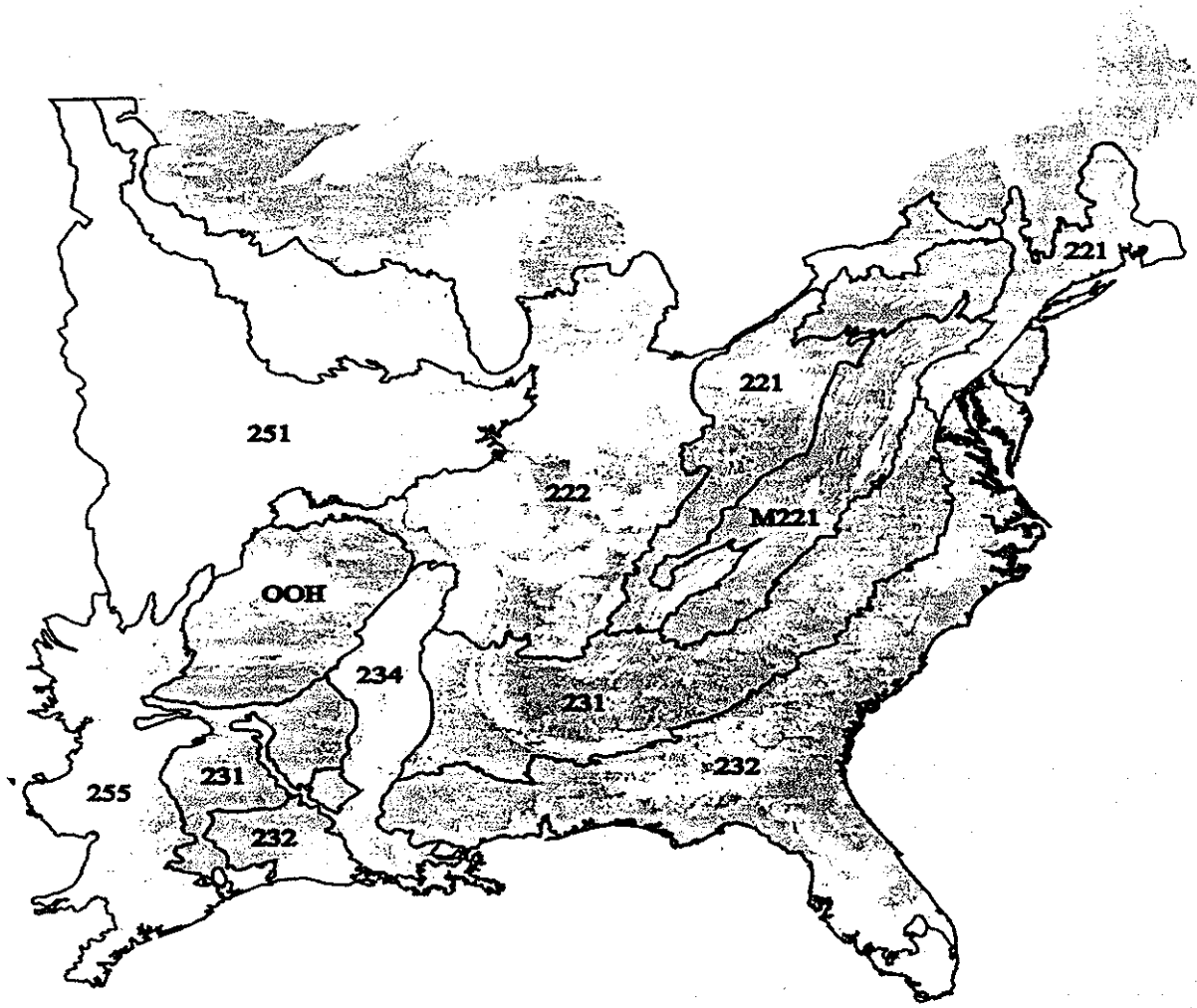
Forest Cover in the Highlands Based on FIA Data

Data Sources and Methods of Analysis

The Forest Inventory and Analysis (FIA) research work units of the USDA Forest Service are the primary sources of data on land use and forest cover types within the Assessment area. The research division of the Forest Service conducts surveys of forest land in each State approximately every 10 years, depending on budgets, available personnel, cooperation by States, and other variables. These surveys supply intensive probability-based sample data available on a regional scale in the United States. Data in these surveys summarize general forest conditions in each State.

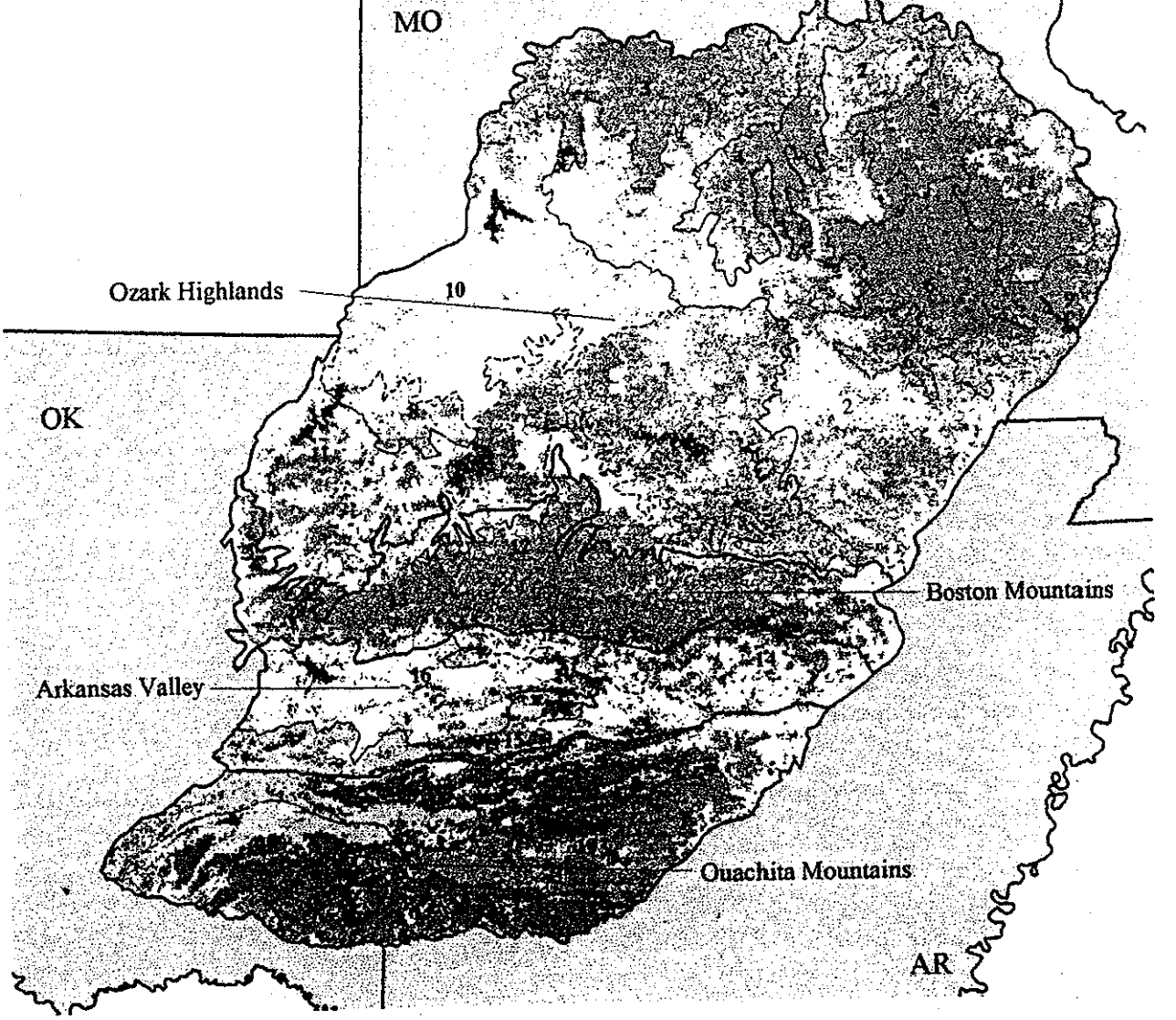
Two separate FIA research units conduct surveys in the Ozark-Ouachita Highlands. The FIA research unit of the Southern Research Station in Starkville, MS, is responsible for surveying forest land in Arkansas and Oklahoma, and the FIA research unit of the North Central Forest Experiment Station, in St. Paul, MN, is responsible for surveying forest land in Missouri.

Forest Inventory and Analysis researchers use a large sampling network of permanent plots on public and private lands across each State. Each plot is revisited and measured on a predetermined schedule. All related data for the plots are combined in a given area (such as a region or State) to provide the general estimate of forest conditions for that area. When recent data from a



OOH	Ozark-Ouachita Highlands Assessment Area
221	Eastern Broadleaf Forest (Oceanic) Province
M221	Central Applachian Broadleaf-Coniferous Forest Meadow Province
222	Eastern Broadleaf Forest (Continental) Province
231	Southern Mixed Forest Province
232	Outer Coastal Plain Mixed Forest Province
234	Lower Mississippi Riverine Forest Province
251	Prairie Parkland Temperate Province
255	Prairie Parkland Subtropical Province

Figure 3.1—Provinces included in the comparison of the Ozark-Ouachita Highlands Assessment area to other portions of the Humid Temperate Domain (the combination of all provinces shown; provinces from McNab and Avers 1994). Shaded areas represent forest; unshaded areas are nonforest.



Ecological section	Map code	Subsection name and number
Ozark Highlands	1	St. Francois Knobs and Basins - 222Aa
	2	Central Plateau - 222Ab
	3	Osage River Hills - 222Ac
	4	Gasconade River Hills - 222Ad
	5	Meramec River Hills - 222Ae
	6	Current River Hills - 222Af
	7	White River Hills - 222Ag
	8	Elk River Hills - 222Ah
	9	Black River Ozark Border - 222Al
	10	Springfield Plain - 222Am
	11	Springfield Plateau - 222An
Boston Mountains	12	Upper Boston Mountains - M222Aa
	13	Lower Boston Mountains - M222Ab
Arkansas Valley	14	Eastern Arkansas Valley - 231Ga
	15	Western Arkansas Valley Mountains - 231Gb
	16	Western Arkansas Valley - 231Gc
Ouachita Mountains	17	Fourche Mountains - M231 Aa
	18	Western Ouachita Mountains - M231Ab
	19	Central Ouachita Mountains - M231Ac
	20	Athens Piedmont Plateau - M231Ad

Cover types

- Loblolly-shortleaf pine
- Oak-pine
- Oak-hickory
- Oak-gum-cypress
- Elm-ash-cottonwood
- Nonforest
- Water

Figure 3.2—Generalized land cover of the Assessment area based on AVHRR data.

Table 3.1—Land cover statistics for the Ozark-Ouachita Highlands, surrounding ecological provinces, and the Eastern United States, based on AVHRR data

Habitat type	Ecological region									
	OOH	221	M221	222	231	232	234	251	255	Eastern U.S.
	Percent									
White-red-jack pine	0.0	5.3	1.8	0.5	0.0	0.0	0.0	0.0	0.0	2.0
Spruce-fir	0.0	0.9	0.3	0.0	0.0	0.0	0.0	0	0.0	1.7
Longleaf-slash pine	0.0	0.0	0.0	0.0	0.5	14.7	0.1	0	0.0	2.3
Loblolly-shortleaf pine	9.9	0.1	0.9	0.1	29.3	15.9	2.9	0	0.5	6.0
Oak-pine	10.8	5.3	11.9	1.0	19.0	8.2	1.3	0	1.5	4.8
Oak-hickory	35.4	37.4	50.9	13.8	17.3	4.1	2.5	2.6	9.5	12.1
Oak-gum-cypress	0.4	0.0	0.0	0.2	3.7	15.6	12.3	0	0.5	3.3
Elm-ash-cottonwood	0.9	0.0	0.0	1.8	0.0	0.0	0.2	1.2	0.0	0.5
Maple-beech-birch	0.0	8.5	5.3	5.2	0.1	0.0	0	0.4	0.0	5.7
Nonforest	40.3	41.5	28.6	75.7	28.4	40.3	79.3	95.3	85.8	51.9
Water	2.3	1.0	0.2	0.8	1.6	1.3	1.4	0.4	1.3	7.4
Total	57.4	57.6	71.1	23.5	69.9	58.5	19.3	4.3	12.8	40.9
	Thousand square miles									
Total area	64.3	95.2	65.5	232.2	167.2	210.2	47.5	200.5	88.8	1,413.5
	Square miles									
Mean forest patch size	2,828	2,764	9,095	430	6,487	3,310	868	87	419	—

AVHRR = Advanced Very High Resolution Radiometer; OOH = Ozark-Ouachita Highlands; 221 = Eastern broadleaf forest oceanic province; M221 = Central Appalachian broadleaf-coniferous forest meadow province; 222 = Eastern broadleaf forest continental province; 231 = Southern mixed forest province; 232 = Outer coastal plain mixed forest province; 234 = Lower Mississippi riverine forest province; 251 = Prairie parkland temperate province; 255 = Prairie parkland subtropical province; Eastern U.S. = Humid temperate domain (all but OOH from McNab and Avers 1994); — = not calculated.

given plot are compared with previous survey data, changes in forest condition can be determined. Details of the procedures used in collecting and analyzing FIA data can be found in Hansen and others (1992).

As with all sample-based information, survey data are subject to sampling errors. For most of the analyses in this section, survey data are based on a large number of plots, and sampling errors will generally be low. For example, the sampling error estimates for growing-stock volume by region is ± 5 percent.

The most recent reports of surveys in the Assessment area were in different years—Arkansas in 1997, Oklahoma in 1993, and Missouri in 1988 (table 3.2). (A new survey was under way in Missouri at the time of the Ozark-Ouachita Highlands Assessment.) The respective FIA units pooled data from those surveys to provide information about the Assessment area.

The Terrestrial Team performed three analyses of increasing complexity. The first analysis characterized forested conditions in the Assessment area, based on the most recent FIA data available. Only FIA sample plots within the Assessment area boundary were used. Thus, the current view is based on data obtained in Arkansas from 1995 to 1997, in Oklahoma in 1993, and in Missouri in 1988 (USDA FS 1997).

The second analysis evaluated changes in land use and forest cover in the Assessment area. Because historical plot data were inconsistent across States, it was impossible to develop a specific link to the Assessment area boundary. Therefore, the Team had to use

Table 3.2—FIA survey regions, survey years, and measurement intervals used for analysis of general trends in forest cover of the Assessment area

State (survey regions)	Year of field work	Measurement interval[a]
Oklahoma (East[b])	1956	1950's
	1966	1960's
	1976	1970's
	1986	1980's
	1993	1990's
Arkansas (Ouachita and Ozark)	1959	1950's
	1969	1960's
	1978	1970's
	1988	1980's
	1995	1990's
Missouri (Eastern Ozarks, Northwest Ozarks, Southwest Ozarks)	1947	1950's
	1959	1960's
	1972	1970's
	1988	1980's

[a] Measurement interval indicates how measurement year was stratified for analysis of trends over time.
[b] Combination of northeast and southeast Oklahoma regions.
Source: USDA FS (1997).

the traditional FIA regions, which correspond reasonably well with the Ozark-Ouachita Highlands (fig. 3.3).

The third analysis was an ecological assessment of forest cover in the Assessment area based on the most recent forest surveys. FIA data were stratified by ecological section and subsection (see following paragraph and, for more detail, Chapter 1) by locating FIA plots within these boundaries using a Geographic Information System (GIS). Plots within each subsection in the Assessment area were retained for analysis. By using this method, a separate FIA data set was prepared for the Assessment.

The sections included in the Assessment area are, from north to south: (1) the Ozark Highlands, (2) the Boston Mountains, (3) the Arkansas Valley, and (4) the Ouachita Mountains. Each section consists of several ecological subdivisions, called "subsections" (see fig. 3.2 or, for a simpler image, fig. 1.1 in Chapter 1), which represent areas of unique geological and ecological character. FIA data were used to evaluate each section in detail and to compare the sections with one another; subsections were compared where data permitted.

Assessment Area

Current Forested Area. According to FIA data, the Assessment area encompasses 37,286,600 acres (ac). Of this, 23,954,800 ac (more than 64 percent) are forested, and 13,331,400 ac (about 36 percent) are in nonforest uses such as agriculture, roads, towns, or cities (fig. 3.4).

Of the forested area, more than 95 percent is classified as timberland, which is land producing or capable of producing commercial timber harvests. Woodlands too unproductive to support commercial timber harvests and forests where timber harvests have been prohibited (Federal wilderness and other "reserved" areas) account for the remainder.

Land Ownership. Nonindustrial private forest (NIPF) owners, such as farmers, urban or suburban residents, and corporations not involved in the timber industry, hold 68 percent of the 22.89 million ac of timberland in the Assessment area; forest industry owns 11 percent (fig. 3.5). Thus, private and corporate landowners together hold 79 percent of the timberland.

Of the 21 percent of timberlands on public lands, 75 percent (16 percent of all timberlands) are in the National Forest System (i.e., part of the Mark Twain, Ouachita, or Ozark-St. Francis National Forests). The remaining 25 percent of public timberland consists of Federal, State, county, and municipal lands, including State forests, wildlife management areas, national wildlife refuges, military bases, and local parks.

General Attributes of Highlands Forests. Hardwoods are the dominant cover on 85 percent of the timberland in the Assessment area (fig. 3.6). The oak-hickory forest type is the most common in the region, occupying 67 percent of the timberland. Pine types, primarily shortleaf and loblolly pines, occupy only 15 percent of the timberland. Of this amount, 65 percent is in shortleaf pine stands of natural origin, and 35 percent is in plantations of either shortleaf or loblolly pine.

The timberlands in the Assessment area occupy relatively poor sites. Most of the timberland acres fall in the two lowest productivity classes; less than 2 percent fall within the two highest productivity classes (fig. 3.7).

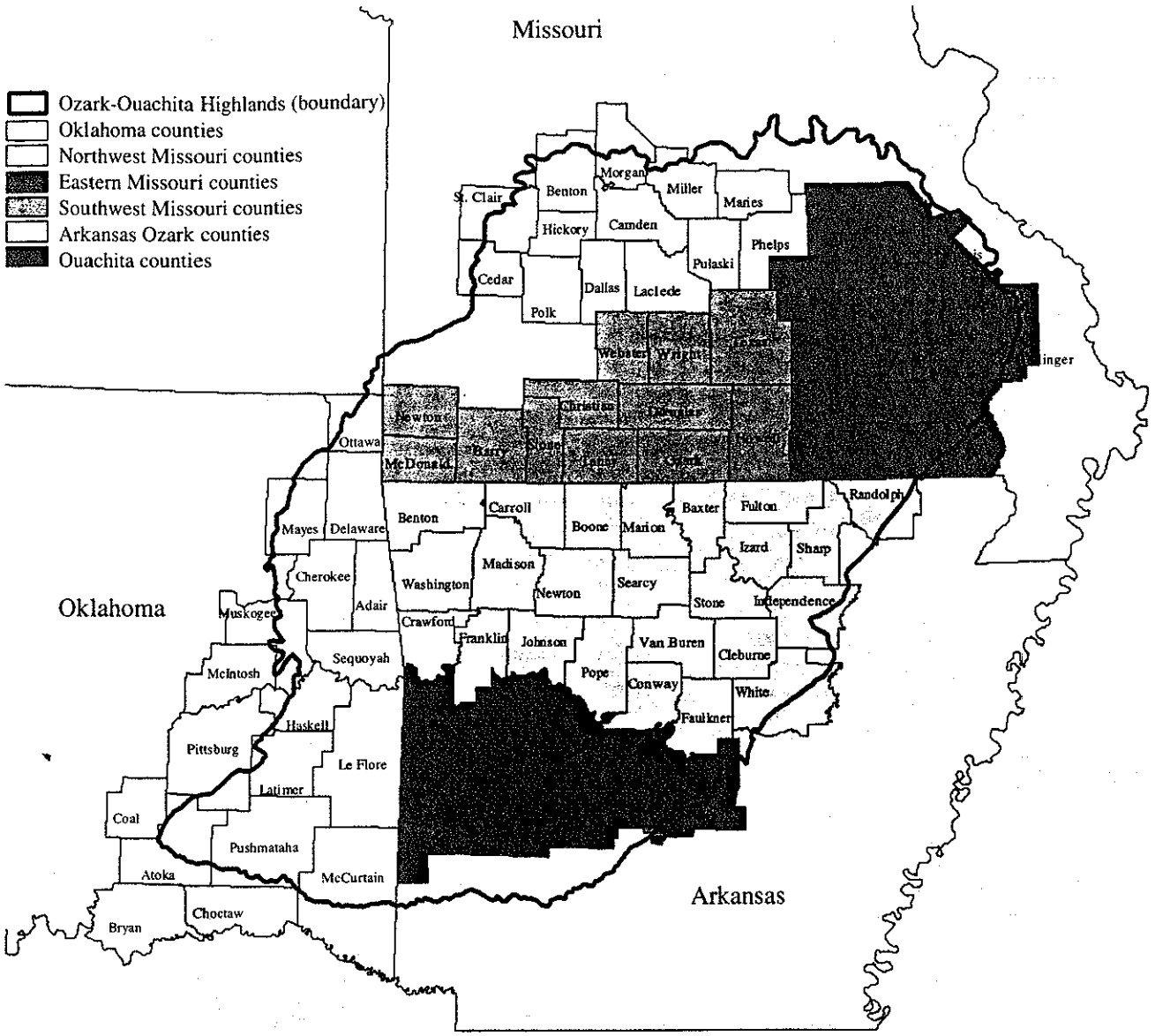


Figure 3.3—FIA regions lying wholly or partially within the Assessment area.

However, the forests within the Assessment area are, on average, adequately stocked (fig. 3.8). (Stocking is a relative measure of the degree to which the growth potential of the site is used by trees; for more information, refer to Hansen and others 1992.) Forests on more than 50 percent of the timberlands have stocking from 60 to 100 percent. Less than 33 percent of the timberlands are less than fully stocked (less than 60 percent stocking), and about 17 percent of the area is overstocked (greater than 100 percent stocking).

FIA analysts distinguish between live trees (all living trees), growing-stock trees (live trees of commercial species and potentially useful for harvest), and sawtimber trees (growing-stock trees large enough to use for saw logs) (Rosson and London 1997). Generally, live-tree comparisons best reflect the species composition and distribution of the forest. Growing-stock comparisons reflect the commercial or merchantable component of the forest, i.e., those trees that are suitable for pulpwood or saw logs. Sawtimber comparisons indicate

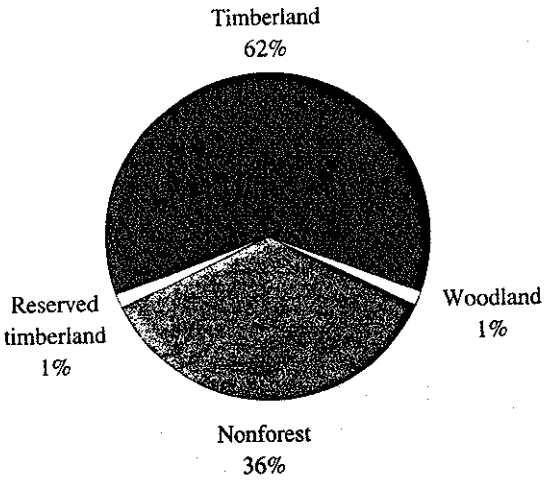


Figure 3.4—Distribution of land cover in the Ozark-Ouachita Highlands.

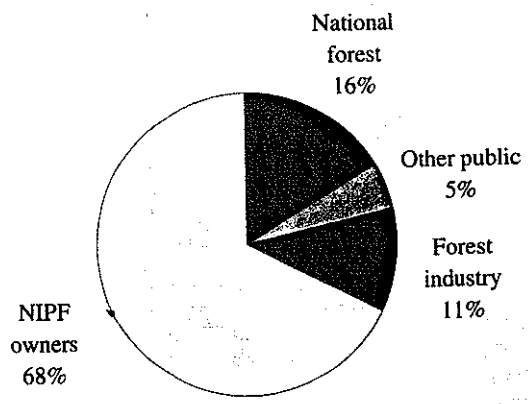


Figure 3.5—Ownership of timberland in the Ozark-Ouachita Highlands. (NIPF = nonindustrial private forest.)

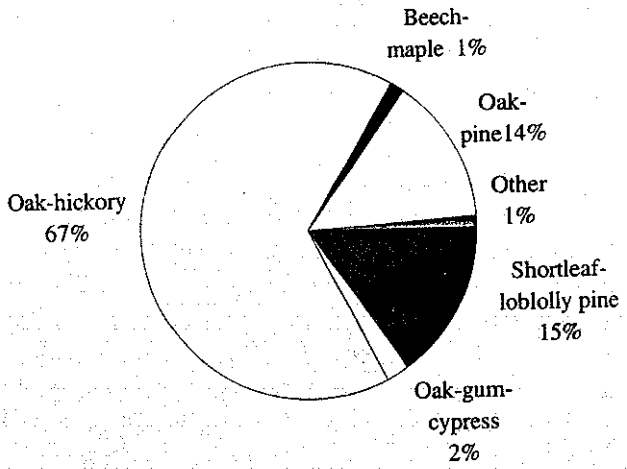


Figure 3.6—Representation of major forest types on timberland in the Ozark-Ouachita Highlands.

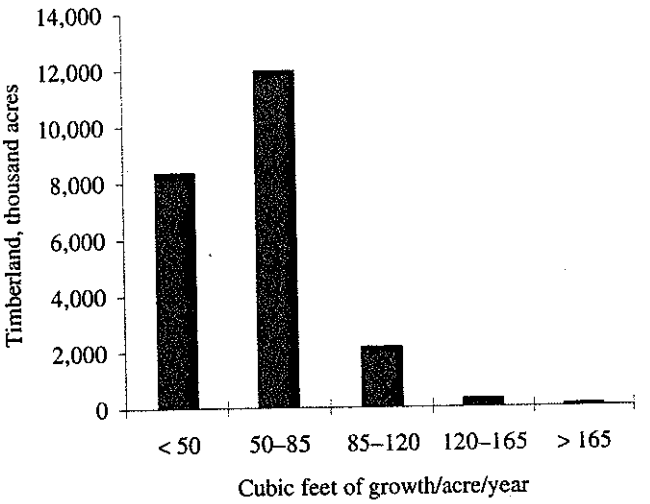


Figure 3.7—Area of timberland in the Ozark-Ouachita Highlands in five site productivity classes.

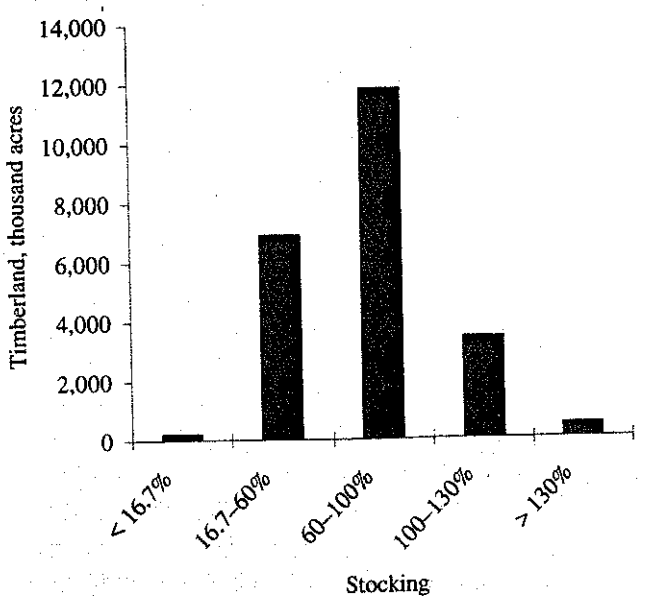


Figure 3.8—Area of timberland in the Ozark-Ouachita Highlands in five stocking classes.

forest conditions associated with large trees (trees 9 inches [in.] in diameter at breast height [d.b.h.] and larger) that are suitable for saw logs.

The average acre in the Assessment area contains 639 live trees, of which 200 trees are in the growing-stock category. Hardwoods account for 77 percent of live trees and 76 percent of growing-stock trees. The average live-tree volume in the Assessment area is 1,032 cubic feet/ac, of which 74 percent is hardwood and 26 percent conifer (pines and eastern red cedar) (table 3.3). Cubic volume decreases from live-tree to growing-stock to sawtimber categories. The distribution of cubic volume also changes, with the percentage of hardwoods declining and percentage of conifers increasing. Finally, the average acre in the Assessment area contains a sawtimber volume of 2,350 board feet (40 percent pine and 60 percent hardwood).

The five species with the largest live-tree volumes in the Assessment area are shortleaf pine, white oak, black oak, post oak, and northern red oak (table 3.4). Together, these five species account for 67 percent of the live-tree cubic volume, 70 percent of the growing-stock volume, and 76 percent of the sawtimber board-foot volume in the Assessment area. Oaks as a group (those just noted

Table 3.3—Average per-acre volumes (live tree, growing stock, sawtimber) of conifers and hardwoods in Assessment area timberlands

Tree type	Live-tree volume	Growing-stock volume	Sawtimber cubic volume	Sawtimber board-foot volume
	Cubic feet/acre			*Board feet/acre*[a]
Conifer	269.7 (26.1%)	261.1 (32.1%)	154.3 (39.2%)	929.6 (39.6%)
Hardwood	762.5 (73.9%)	552.8 (67.9%)	239.3 (60.8%)	1,420.4 (60.4%)
Total	1,032.2 (100%)	813.9 (100%)	393.6 (100%)	2,350.0 (100%)

[a] International ¼-inch rule.
Source: USDA FS (1997).

Table 3.4—Distribution of live-tree and sawtimber volume among major tree species in the Assessment area

Species	Live-tree volume		Sawtimber volume	
	Cubic feet/acre	*Percent*	*Board feet/acre*	*Percent*
Shortleaf pine	214.4	20.7	847.6	35.9
White oak	172.1	16.6	339.0	14.4
Black oak	140.8	13.6	317.5	13.5
Post oak	117.0	11.3	142.4	6.0
Northern red oak	53.0	5.1	140.1	5.9
Loblolly pine	39.5	3.8	69.3	2.9
Scarlet oak	24.1	2.3	49.7	2.1
Sweetgum	20.9	2.0	55.2	2.3
Blackjack oak	19.9	1.9	5.8	0.2
Southern red oak	18.2	1.8	48.9	2.1
Other species	214.3	20.7	344.8	14.6
Total	1,034.1	100	2,360.3	100

Source: USDA FS (1997).

and scarlet, blackjack, chinquapin, and southern red oak) account for about 50 percent of the live-tree volume and 44 percent of the sawtimber volume in the Assessment area. Shortleaf pine alone, however, accounts for 36 percent of the board-foot volume in area. Almost 50 percent of the shortleaf pine sawtimber board-foot volume in the Assessment area (9.56 billion board feet) is located on national forest land.

Loblolly pine is the sixth-ranked species and accounts for 3.8 percent of the live-tree volume in the Assessment area. This species is native only to a handful of counties along the southern boundary of the Assessment area, but it is commonly used in intensive plantation management by forest industry to the north of its natural range, especially in the Ouachita Mountains.

Distribution of Volume in the Assessment Area. Eighty percent of the growing-stock volume consists of oaks (50 percent) and pines (30 percent)(fig. 3.9).

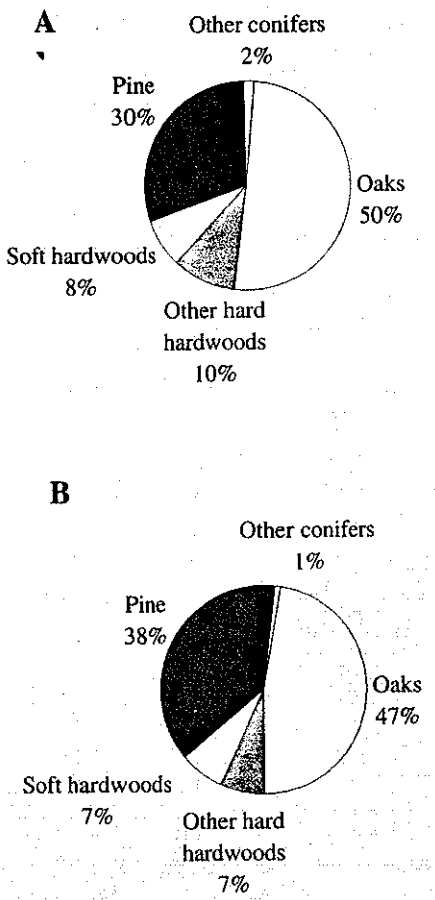


Figure 3.9—Distribution of (A) growing-stock volume and (B) sawtimber volume in the Ozark-Ouachita Highlands by species group.

Eighty five percent of the board-foot sawtimber volume is oak (47 percent) or pine (38 percent). More than 50 percent of the growing-stock volume and sawtimber volume are in hard hardwoods (primarily oaks but also hickories, hard maple, beech, ashes, and black walnut). Soft hardwoods (soft maples, sweetgum, tupelo, blackgum, cottonwood, and basswood) account for about 7 percent of the growing-stock and sawtimber volumes in the Assessment area.

Only 30 percent of the timberland acreage in the Assessment area have stand volumes greater than 1,000 cubic feet/ac (fig. 3.10). Ownership of this 30 percent is not typical of the average. National forests account for more than one-third (fig. 3.11), which is disproportionately high, given that national forests occupy just over 16 percent of the Assessment area. Conversely, NIPF landowners own nearly 75 percent of the stands with less than 1,000 cubic feet/ac, another disproportionately high percentage.

Figure 3.12 shows that there are more oaks than pines in the Assessment area throughout the range of diameter classes. Overall, there are 2.8 living oaks for every live pine in the Assessment area. For every live conifer (pines, eastern red cedar), there are 6.6 living

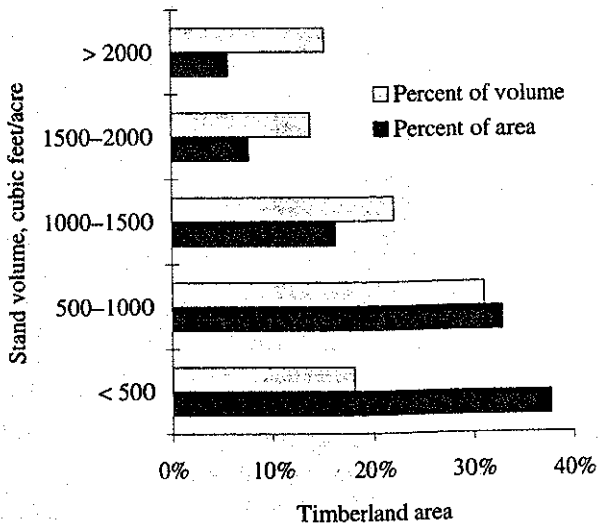


Figure 3.10—Distribution of growing-stock volume and timberland in the Ozark-Ouachita Highlands in stands of various stocking levels.

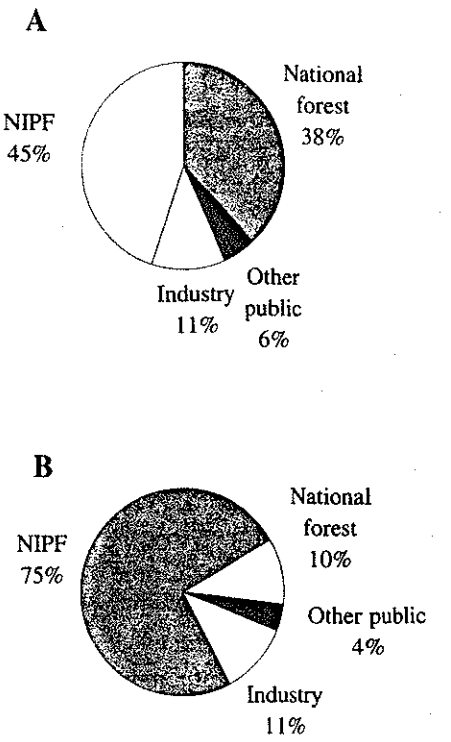


Figure 3.11—Ownership of forest stands in the Ozark-Ouachita Highlands with (A) greater than and (B) less than 1,000 cubic feet of growing-stock volume per acre.

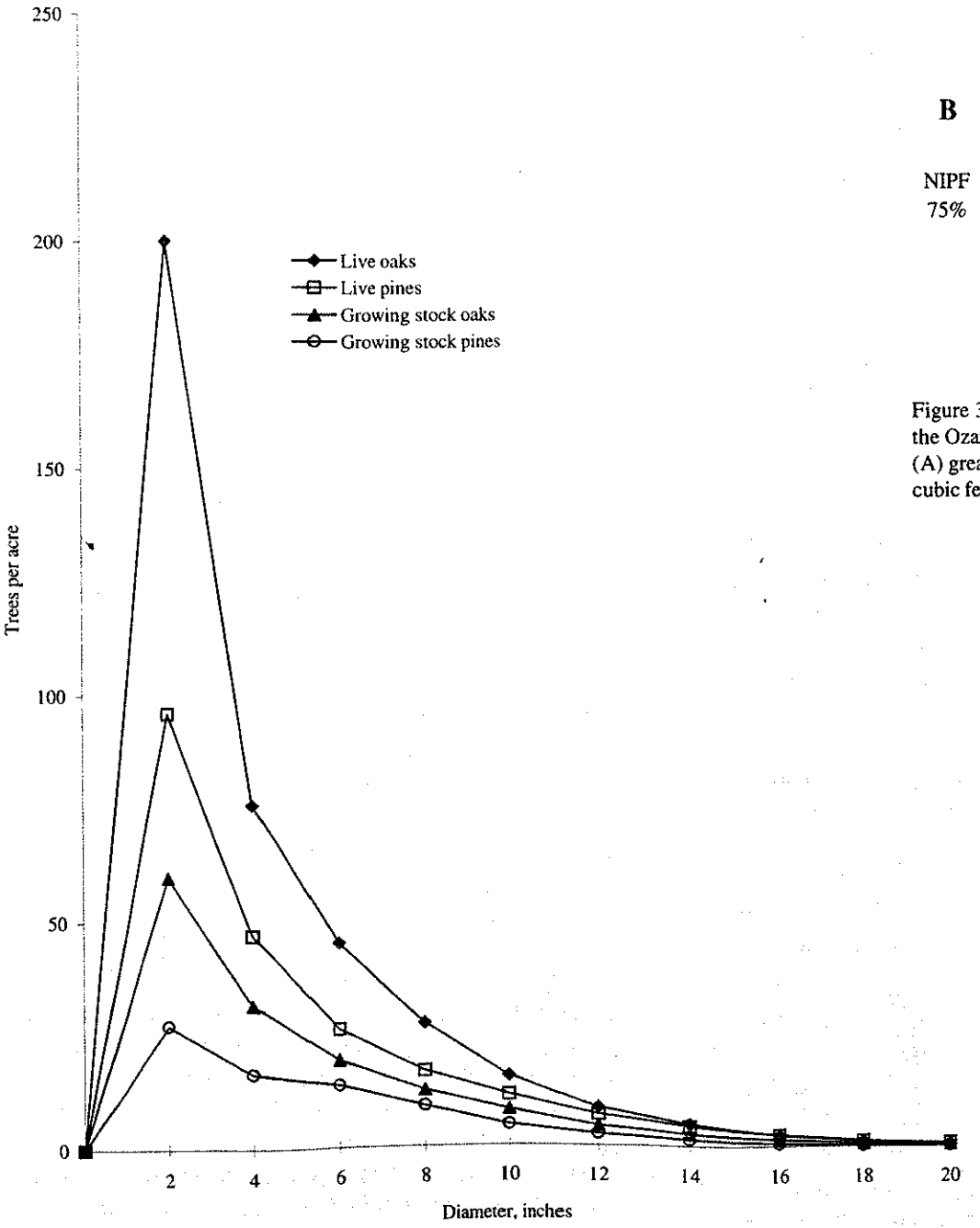


Figure 3.12—Size-class distribution of oak and pine trees per acre on timberland in the Ozark-Ouachita Highlands.

hardwoods. However, the proportion of conifers of growing-stock quality (merchantable or sawtimber category) is considerably higher than for hardwoods (table 3.5). For conifers in general and pines in particular, the ratio of growing-stock trees to live trees exceeds 80 percent in all diameter classes and 95 percent in the sawtimber size class. Conversely, the ratio does not exceed 70 percent for oaks in any of the broad size categories.

FIA analysts divide the live trees that are not of growing-stock quality into two categories: (1) rough trees, too gnarly or branched to qualify as growing stock, and (2) rotten trees, which have excessive internal defect. The volume of rough and rotten trees in proportion to growing-stock trees is much greater in the hardwood component, especially the hard hardwoods, than in the pine or other conifer components (fig. 3.13).

These data suggest that a larger proportion of the pines have potential commercial value than do oaks (or hardwoods in general) in the Assessment area. There are several causes for this trend. The determinate growth form of conifers—the tendency of conifers to produce a single stem—makes it easy to classify a conifer as having potential commercial value early in the tree's life. Conversely, the indeterminate growth habit of hardwoods—the tendency of hardwoods to form a crooked stem or multiple stems under partially shaded conditions—can result in a tree developing poor form,

Table 3.5—Percent of live trees that qualify as growing-stock trees by size category and species group

Species group	All species[a]	Merchantable[b]	Sawtimber[c]
	Percent		
Pine	82.7	90.7	97.4
All conifers	83.3	89.3	95.4
Oak	66.1	69.1	64.9
All hardwoods	58.5	64.1	65.1
All trees	59.7	68.7	71.7

[a] "All sizes" consist of diameter classes 2 in. and larger.
[b] Merchantable size classes are diameter classes 4 in. and larger in the conifer components and 6 in. and larger in the hardwood components.
[c] Sawtimber size classes are diameter classes 10 in. and larger in the conifer components and 12 in. and larger in the hardwood components.
Source: USDA FS (1997).

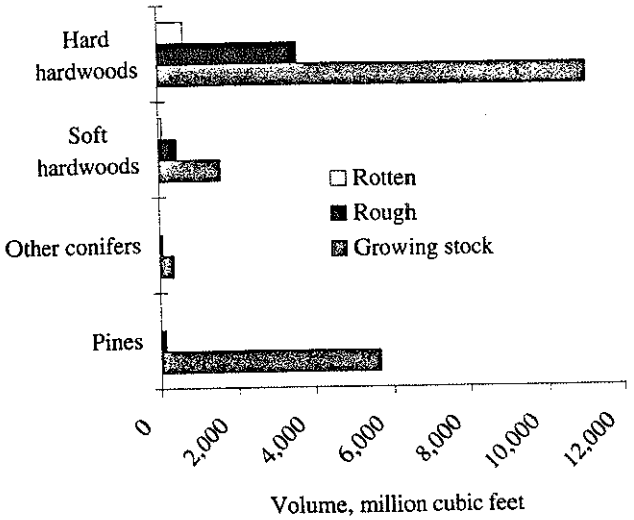


Figure 3.13—Growing-stock volume, rough tree volume, and rotten tree volume in the Ozark-Ouachita Highlands by species group.

which reduces its commercial value. However, lack of commercial value in no way diminishes the other resource values trees provide, including mast crops and cavities for use by wildlife.

Growth, Removals, and Mortality. The average acre in the Ozark-Ouachita Highlands supports an annual net growth of 29.6 cubic feet, most of which (85 percent) is in the pine and oak components (fig. 3.14). Average annual removals by harvesting amount to 14.5 cubic feet/ac, of which 88 percent is in the pine and oak components. The net result is that growth on the average acre in the Assessment area is more than double the removals. The oak component has a larger growth-removals ratio than the pines, 6.9 versus 5.3 cubic feet/ac per year.

The average annual mortality rate is 12.3 percent of the gross annual growth (3.7 cubic feet). However, mortality rates differ between conifers and hardwoods—5.8 percent and 17.4 percent of gross annual growth, respectively. Removals through harvest exceed natural mortality by only 1.6 times in the hardwood component but by over 9 times in the conifer component.

Differences Among Ecological Sections. The Ozark Highlands section dominates the Assessment area, containing 22.87 million ac or 61 percent of the total land area (fig. 3.15). The other three sections—the

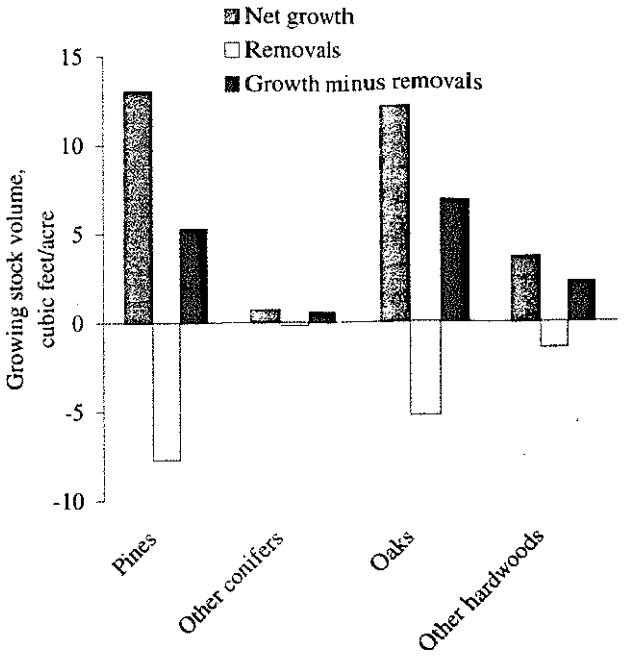


Figure 3.14—Average net annual growth, average annual removals, and growth minus removals for the average timberland acre in the Ozark-Ouachita Highlands.

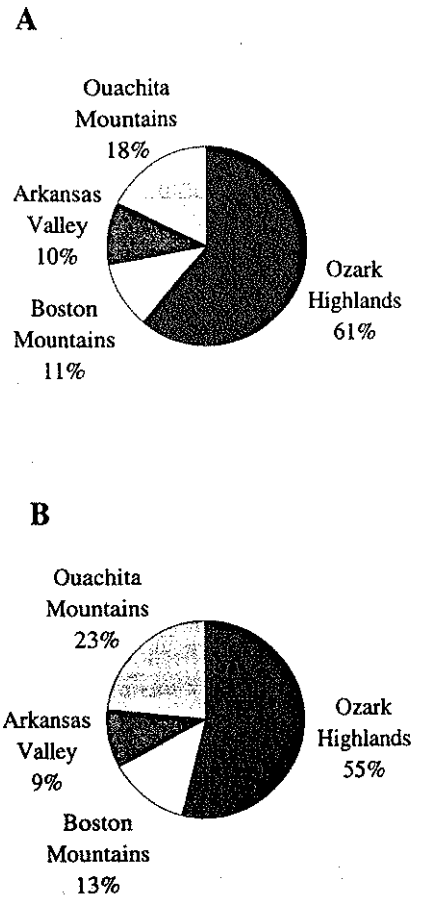


Figure 3.15—Distribution of (A) total land area and (B) forested land area in the Ozark-Ouachita Highlands by ecological section.

Ouachita Mountains, the Boston Mountains, and the Arkansas Valley—occupy 18 percent, 11 percent, and 10 percent, respectively, of the area. Of the 23.95 million ac of total forest and in the Assessment area, more than 50 percent are in the Ozark Highlands, again followed in rank order by the Ouachita Mountains, the Boston Mountains, and the Arkansas Valley. Total area, forest land, and timberland acreage by section and subsection are shown in table 3.6.

Within each section, the amount of forested land differs considerably (fig. 3.16). In the Ozark Highlands, only 56 percent of the land area is forested versus 60 percent in the Arkansas Valley, 78 percent in the Boston Mountains, and 85 percent in the Ouachita Mountains. The ratio of timberland to total forest land shows the small amount of reserved forest land (such as wilderness areas) and "other forest" in the Assessment area. More than 95 percent of the forested area is commercial timberland, i.e., capable of supporting commercial timber harvests.

Private lands held by NIPF owners and forest industry dominate the timberland acreage in the four

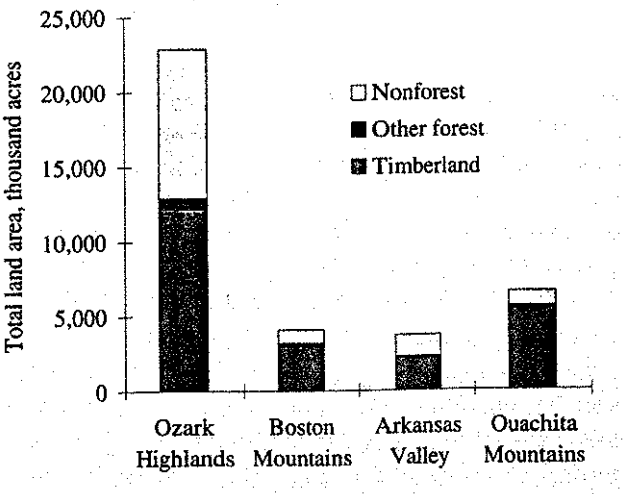


Figure 3.16—Distribution of total land area in the ecological sections of the Ozark-Ouachita Highlands by land category.

Table 3.6—Total land area, forested land area, and timberland area by ecological section and subsection in the Ozark-Ouachita Highlands (FIA data)

Ecological section Subsection[a]	Map code	Total land	Forest land	Timberland
		Thousand acres		
Ozark Highlands Section	222	22,780.9	12,901.8	12,189.8
St. Francois Knobs and Basins	222Aa	1,092.1	750.2	688.0
Central Plateau	222Ab	6,338.7	3,099.1	3,013.9
Osage River Hills	222Ac	1,399.2	855.3	778.9
Gasconade River Hills	222Ad	1,087.5	654.3	612.9
Meramac River Hills	222Ae	1,168.1	891.4	881.6
Current River Hills	222Af	1,563.3	1,322.0	1,215.7
White River Hills	222Ag	3,583.7	2,342.8	2,121.6
Elk River Hills	222Ah	434.0	264.2	264.2
Black River Ozark Border	222Al	860.7	677.1	665.7
Springfield Plain	222Am	3,103.1	641.8	634.0
Springfield Plateau	222An	2,240.4	1,403.6	1,313.3
Boston Mountains Section	M222	4,090.1	3,181.7	3,035.3
Upper Boston Mountains	M222Aa	1,129.7	904.9	837.0
Lower Boston Mountains	M222Ab	2,960.3	2,276.8	2,198.3
Arkansas Valley Section	231	3,725.1	2,253.3	2,192.8
Eastern Arkansas Valley	231Ga	1,470.1	774.3	754.8
Mount Magazine	231Gb	664.1	616.8	592.8
Western Arkansas Valley Mountains	231Gc	1,590.9	862.2	845.2
Ouachita Mountains Section	M231	6,600.1	5,617.9	5,477.0
Fourche Mountains	M231Aa	2,740.8	2,147.3	2,050.6
West Central Ouachita Mountains	M231Ab	1,443.2	1,421.8	1,406.8
East Central Ouachita Mountains	M231Ac	1,526.6	1,292.4	1,263.2
Athens Piedmont Plateau	M231Ad	889.5	756.4	756.4
Total		37,286.2	23,954.8	22,894.9

[a] See figure 1.1 for locations.
Source: USDA FS (1997).

sections (fig. 3.17). In each section, more than 70 percent of timberland is in private ownership. In the Ozark Highlands and the Arkansas Valley, this figure exceeds 83 percent. However, the character of private ownership differs by section. In the Ozark Highlands, Boston Mountains, and the Arkansas Valley, more than 96 percent of the private timberlands are in NIPF ownership. But in the Ouachita Mountains, NIPF owners own slightly less than one-half of the private sector timberlands. Forest industry owns more than 2 million ac of timberland in the Ouachitas—80 percent of the 2.5 million ac of forest industry timberland in the entire Assessment area.

An examination of the distribution of types of forests shows hardwood forests are more widely distributed than pine-dominated types in each section, but the proportions shift from north to south (left to right in fig. 3.18). Oak or oak-pine forests are dominant on 90 percent of timberland in the Ozark Highlands and Boston Mountains, but they account for 78 percent of the timberland in the Arkansas Valley and 58 percent in the Ouachita Mountains. Generally, the percentage of pine forest acreage increases directly with the decreasing proportion of oak types. This relationship is most evident in the Ouachita Mountains, where pine types occupy slightly over 40 percent of the timberland area.

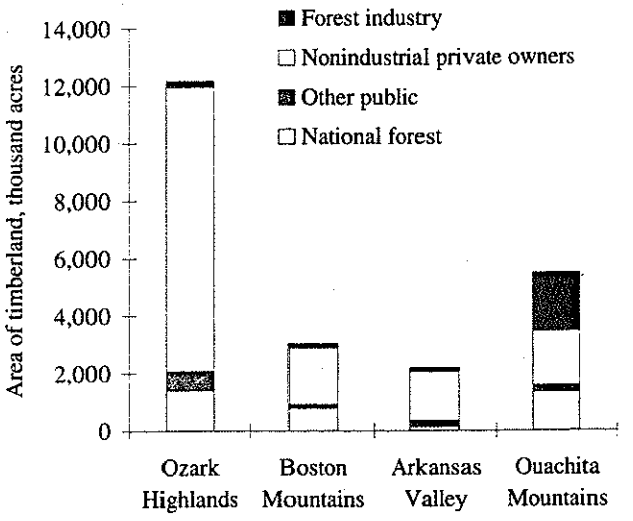


Figure 3.17—Distribution of timberland in the ecological sections of the Ozark-Ouachita Highlands by ownership category.

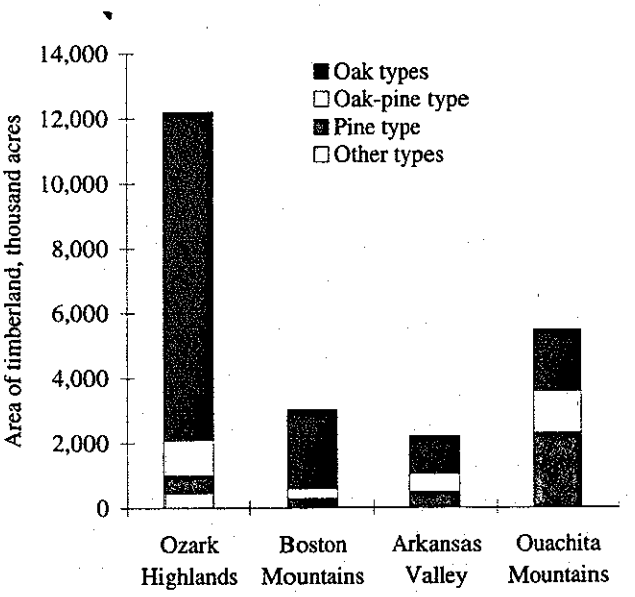


Figure 3.18—Distribution of timberland in the ecological sections of the Ozark-Ouachita Highlands by forest type.

Overall, site productivity is inversely related to latitude, with poorer productivity in the north. This trend is especially apparent in the lowest site productivity class (fig. 3.19). More than 90 percent of the timberland in the Ozark Highlands and the Boston Mountains falls in the two poorest classes. The only section with more than 25 percent of timberland in the moderately productive class (85 to 120 cubic feet/ac per year) is the Ouachita Mountains. Less than 5 percent of the timberland in any section has growth rates exceeding 120 cubic feet/ac per year.

Conversely, stocking of timberland does not differ greatly among sections (fig. 3.20). The Boston Mountains and Ouachita Mountains both have slightly less timberland in understocked stands and slightly more in overstocked stands than the Ozark Highlands or Arkansas Valley sections. However, these differences are not prominent. In addition the percent of area occupied by sawtimber, pulpwood, and seedling-sapling stands is similar across sections. There is a slightly higher percentage of area occupied by stands of sawtimber in the Ozark Highlands and Boston Mountains, but again the differences among sections are not prominent.

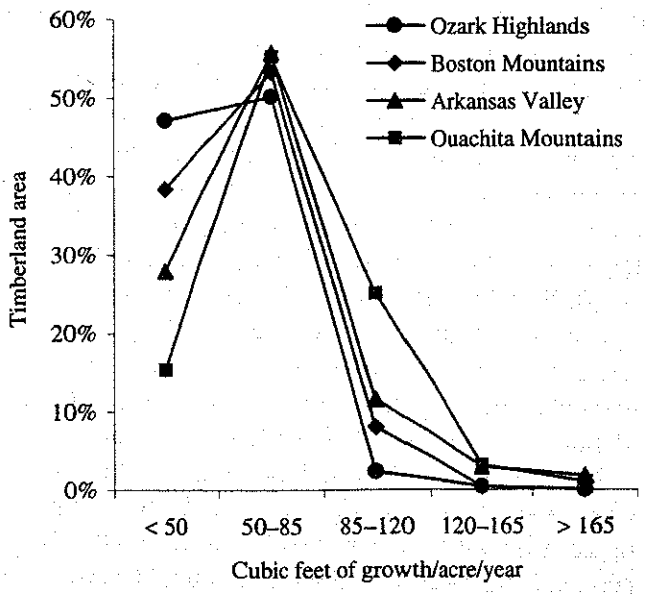


Figure 3.19—Distribution of timberland in the ecological sections of the Ozark-Ouachita Highlands by site quality (productivity) class.

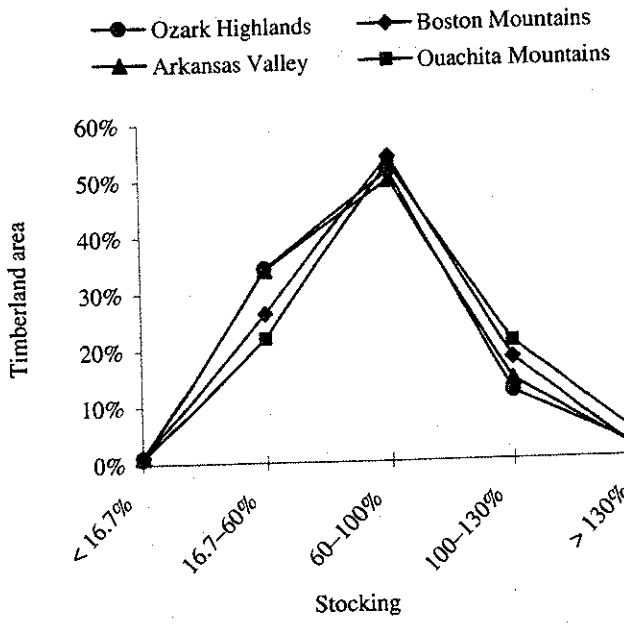


Figure 3.20—Distribution of timberland in the ecological sections of the Ozark-Ouachita Highlands by stocking class.

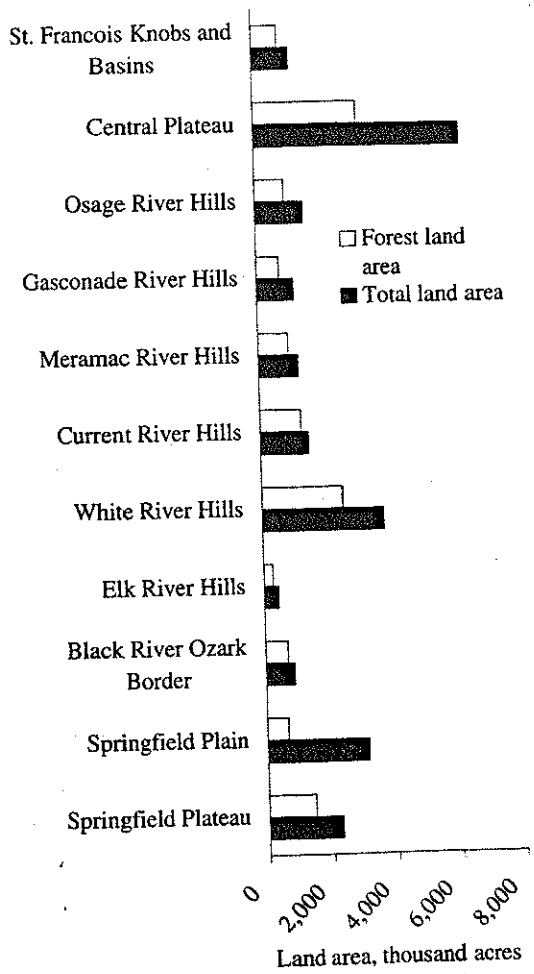


Figure 3.21—Distribution of forested land and total land area of the Ozark Highlands section by ecological subsection.

Ozark Highlands

General Land Attributes. The portion of the Ozark Highlands section that lies within the Assessment area includes 11 ecological subsections. Three of these—the Central Plateau, the White River Hills, and the Springfield Plain—account for more than 50 percent of the land area in this section. The Central Plateau and the Springfield Plain are the only subsections with less than 50 percent of the land area in forest (fig. 3.21). When these two subsections are excluded, the rest of the Ozark Highlands is more than 66 percent forested, a figure close to the Assessment area average. Percentage of land in forest cover varies from a low of 20 percent in the Springfield Plain subsection to a high of 85 percent in the Current River Hills subsection.

NIPF owners hold the majority of timberland in all but one of the subsections (fig. 3.22). NIPF ownership ranges from 49 percent in the Current River Hills to 97 percent in the Elk River Hills. Ten of the 11 subsections have greater than 70 percent NIPF ownership of timberland, and 6 have greater than 85 percent. Conversely, public ownership of timberland varies from 3 percent in the Elk River Hills subsection to just over 50 percent in the Current River Hills subsection. Figure 3.23 shows acres in public ownership by subsection. The four subsections with greater than 20 percent Federal ownership are the Gasconade River Hills, the Meramac River Hills, the Current River Hills, and the Black River Ozark Border. An inverse relationship exists between percent of timberland ownership in the NIPF sector and percent forest cover in this section—the higher the percentage of timberland in NIPF ownership, the lower the percent forest cover.

Oaks, especially the oak-hickory forest type, dominate the timberlands of the Ozark Highlands in all subsections (fig. 3.24). The percentage of oak types (oak-hickory, oak-pine, and oak-gum-cypress) does not fall below 87 percent in any of the subsections.

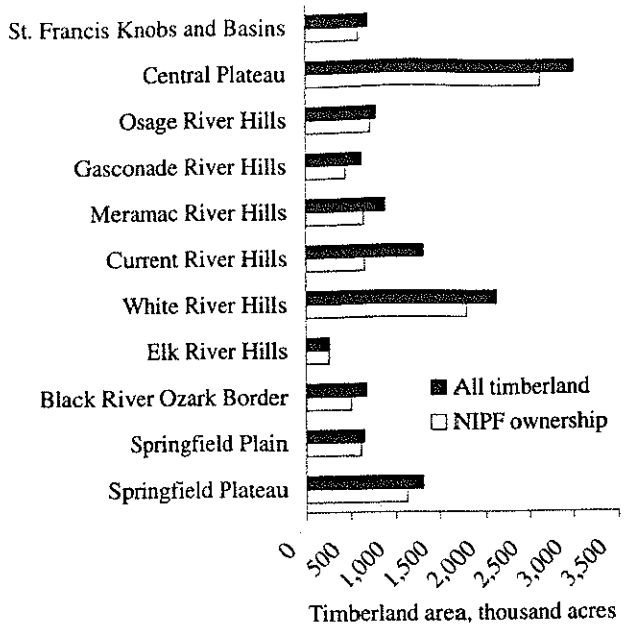


Figure 3.22—Distribution of total timberland and nonindustrial private forest in the Ozark Highlands section by ecological subsection.

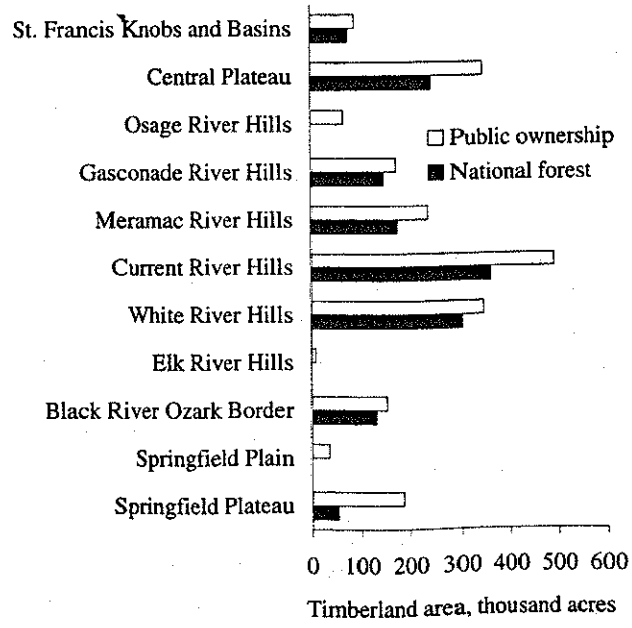


Figure 3.23—Distribution of timberland in public ownership and national forest ownership in the Ozark Highlands by ecological subsection.

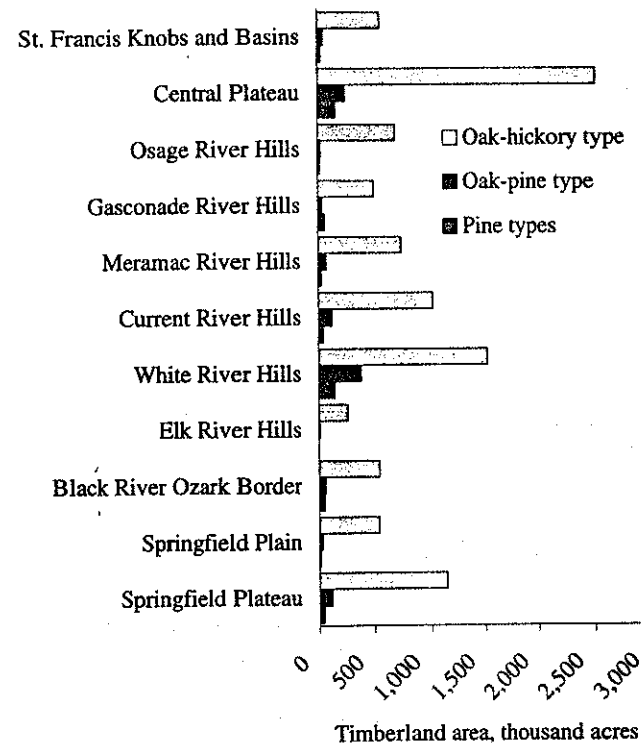


Figure 3.24—Distribution of timberland in the Ozark Highlands by forest type and ecological subsection.

Pine types are a minor component in all subsections, reaching a maximum of 9 percent of timberland area in the Gasconade River Hills subsection. This dominance of oaks is also reflected in growing-stock and sawtimber volume data. Hard hardwoods (such as oaks, hickory, hard maple, and black walnut) account for 81 percent of growing-stock volume and 79 percent of sawtimber board-foot volume on timberland across the Ozark Highlands. The range in hard hardwood volume on timberlands among subsections varies from 74 percent to 94 percent for growing-stock volume and from 71 to 94 percent for sawtimber board-foot volume.

General Forest Attributes. An average acre of timberland in the Ozark Highlands section has 582 live trees, of which 432 trees qualify as growing stock. These data are higher than for the Assessment area as a whole. Nearly 80 percent of the trees are in the 2-in. and 4-in. diameter classes, which is high relative to normal stocking standards. Softwoods account for less than 10 percent of the live trees and 11 percent of growing-stock trees per acre. Live-tree basal area of the average timberland acre is 79.7 square feet, of which 66 percent is in growing stock. The quadratic mean diameter of the average tree on the average timberland acre is 5 in.

More than 33 percent of the timberland area in the Ozark Highlands is either poorly stocked or nonstocked. As shown in fig. 3.25, national forests have the highest proportion of lands either moderately stocked (defined by FIA as between 60 to 100 percent stocked) or fully stocked (defined by FIA as from 100 to 130 percent stocked). The NIPF sector has the lowest proportion of lands in these classes. Further, the NIPF sector has the largest percentage of timberland (39 percent) in the two poorest stocking classes, whereas national forests have the smallest (slightly over 10 percent).

The average timberland acre in the Ozark Highlands has a live-tree volume of 961 cubic feet, a growing-stock volume of 660 cubic feet, a sawtimber cubic volume of 304 cubic feet, and a sawtimber board-foot volume of 1,800 board feet. Thus, the Ozark Highlands appear to have stands with lower volumes, on average, than the Assessment area as a whole (refer to table 3.3 for the latter). The contribution of pine to the volume components increases slightly, from 7 percent of live-tree volume to 14 percent of sawtimber volume, while that of hard hardwoods decreases from 84 percent to 78

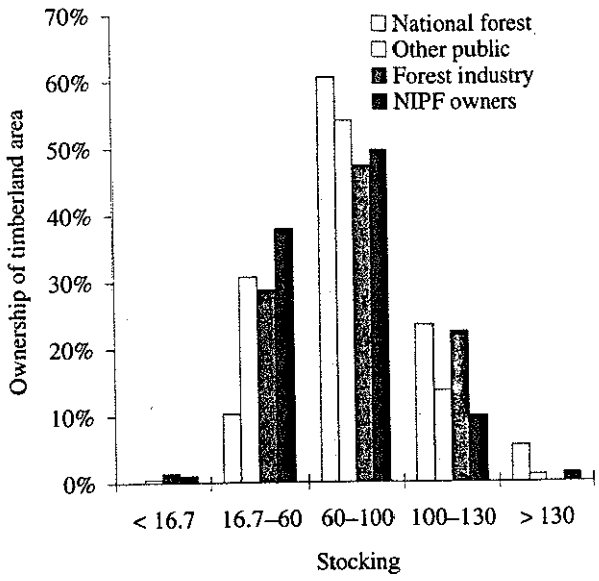


Figure 3.25—Distribution of timberland in the Ozark Highlands by stocking level and ownership category.

percent across the same range. Thus, pine appears to contribute only in a minor way to the character of the average acre in the Ozark Highlands.

The six species with the greatest volumes in the Ozark Highlands are black oak, white oak, post oak, shortleaf pine, scarlet oak, and northern red oak. Together they make up 74 percent of the live-tree volume, 77 percent of the growing-stock volume, and 81 percent of the sawtimber board-foot volume in this section. Almost 24 percent of the growing-stock volume of these six species is found on public lands, which consists of 17 percent of the section's timberland area. Nearly 50 percent of the shortleaf pine and 40 percent of the scarlet oak growing-stock volume in this section are on public lands (fig. 3.26).

Conversely, the NIPF class owns 81 percent of the timberland area but has only 74 percent of the volume. Post oak is the only species on NIPF lands that has a proportional growing-stock volume that exceeds the proportion of timberland. These data suggest that timberland in the public sector supports a disproportionately high share of the growing-stock volume in this section.

Growth, Removals, and Mortality. The Ozark Highlands section shows a growth surplus in the major forest types (fig. 3.27). Average annual net growth per

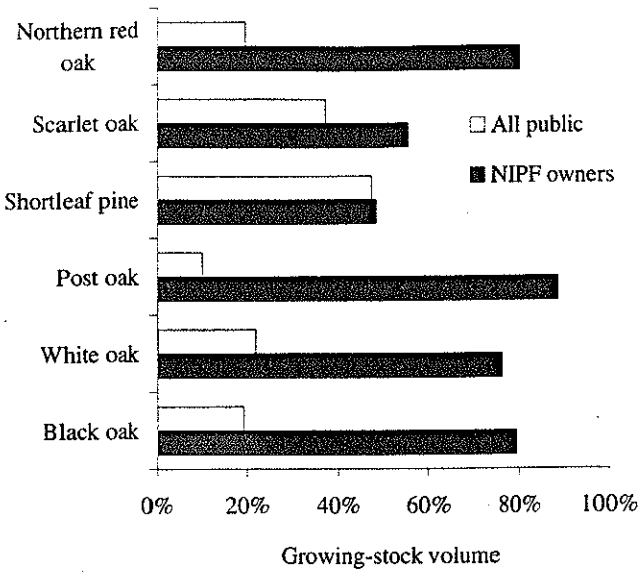


Figure 3.26—Distribution of growing-stock volume on public timberland and nonindustrial private forest land in the Ozark Highlands section.

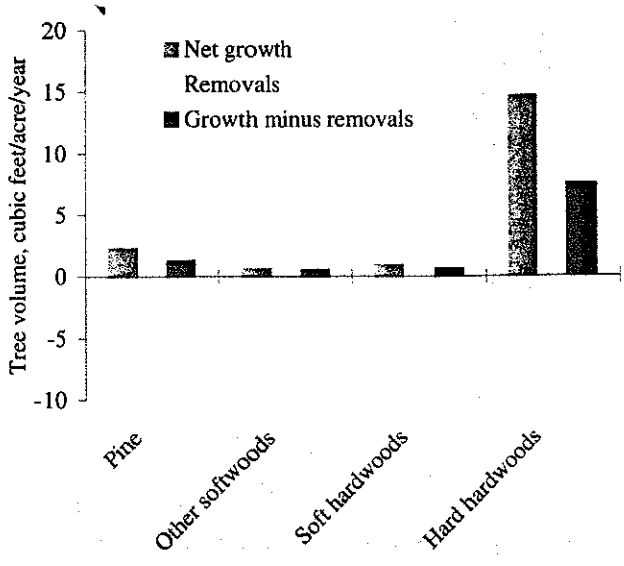


Figure 3.27—Growth, removals, and growth minus removals of growing-stock volume in the Ozark Highlands section by species group.

acre on timberland in this section is 18.8 cubic feet, of which 78 percent is in the hard hardwood component, and 16 percent is in the pine component. Average annual removals per acre total 8.5 cubic feet, of which 82 percent is hard hardwood and 15 percent is pine. Thus, growth exceeds removals by 10.3 cubic feet/ac annually.

Average annual mortality per acre on timberland in this section is 4.1 cubic feet—nearly 18 percent of gross annual growth per acre and slightly less than 50 percent of the level of removals. Hardwood mortality is nearly 20 percent of gross hardwood growth, whereas softwood mortality is 8 percent of growth—less than 50 percent of the mortality rate. The highest mortality rate is in the soft hardwoods—nearly 30 percent of gross growth.

Boston Mountains

General Land Attributes. The Boston Mountains section occupies about 4 million ac. It has two ecological subsections—the Upper Boston Mountains subsection (about 1 million ac) and the Lower Boston Mountains subsection (about 3 million ac). Both are entirely contained within the Assessment area and are about equally forested (fig. 3.28)—80 percent for the Upper Boston Mountains subsection and 77 percent for the Lower Boston Mountains. About the same physical area of each subsection is reserved woodland, which results in a slightly lower proportion of timberland in the Upper Boston Mountains subsection (92 percent) than in the Lower Boston Mountains (97 percent).

Land ownership in the subsections differs slightly (fig. 3.29). More than 33 percent of the Upper Boston Mountains subsection is public land, with 98 percent of that in national forest. The balance of slightly less than 66 percent of the timberland is in private ownership. In the Lower Boston Mountains subsection, about 27 percent of the timberland is public land, of which 84 percent is national forest. Of the 70 percent of Lower Boston Mountains timberland that is in private ownership, 6 percent is owned by forest industry and the balance by NIPF owners.

Forest types also differ in these subsections (fig. 3.30). More than 97 percent of the timberland area in the Upper Boston Mountains subsection is oak-dominated, with more than 92 percent in the oak-hickory

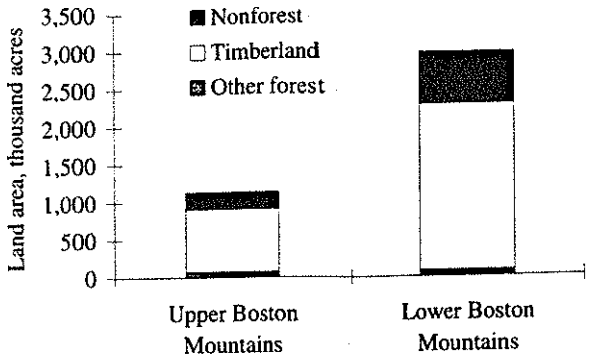


Figure 3.28—Distribution of timberland, other forest land, and nonforest land in the Boston Mountains section by ecological subsection.

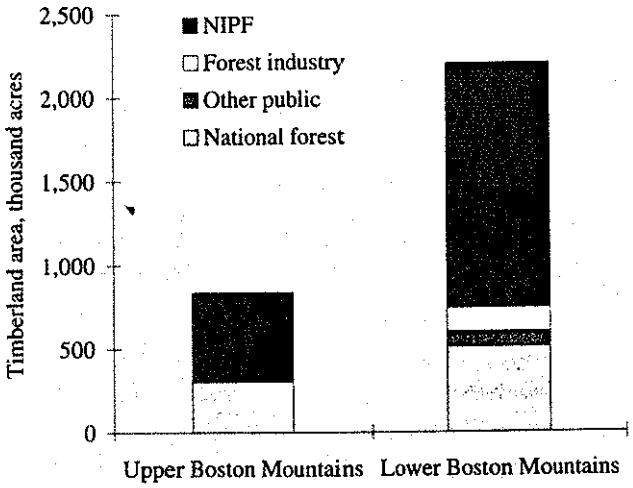


Figure 3.29—Distribution of nonforest land, timberland, and other forest land by ownership category in the Boston Mountains by ecological subsection. (NIPF = nonindustrial private forest)

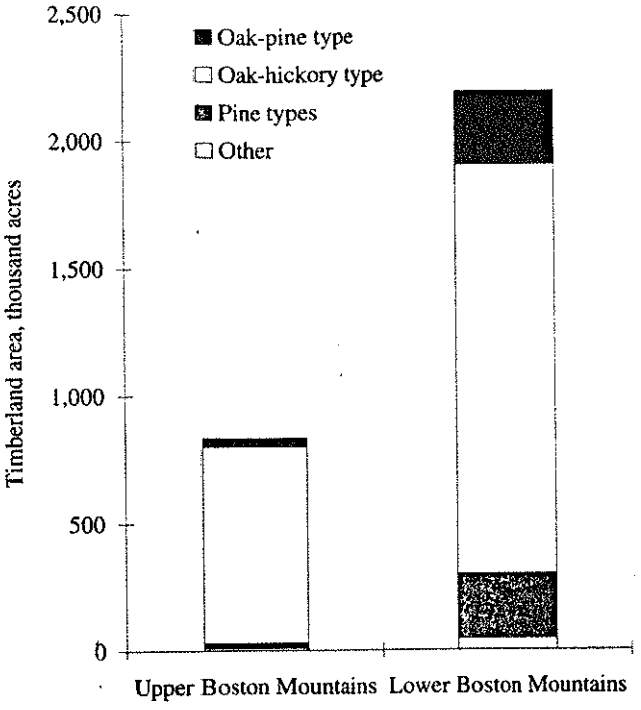


Figure 3.30—Distribution of timberland in the Boston Mountains by forest type and ecological subsection.

type alone. In the Lower Boston Mountains, pine and oak-pine types are more prominent (at 11 and 13 percent, respectively), although oak-hickory remains the most prevalent forest type.

The dominance of oaks in the Upper Boston Mountains and the higher amount of pine in the Lower Boston Mountains are also apparent in growing-stock and sawtimber-volume data (figs. 3.31 and 3.32). Hard hardwoods make up 82 percent of the growing-stock volume in the Boston Mountains and 80 percent of the sawtimber board-foot volume. These percentages are almost identical to those in the Ozark Highlands section. However, hard hardwoods only make up 64 percent of growing-stock volume and 58 percent of sawtimber board-foot volume in the Lower Boston Mountains subsection.

Conversely, pine increases from less than 5 percent of growing-stock volume and 6 percent of sawtimber board-foot volume in the Upper Boston Mountains to 20 percent of the growing-stock volume and more than 25

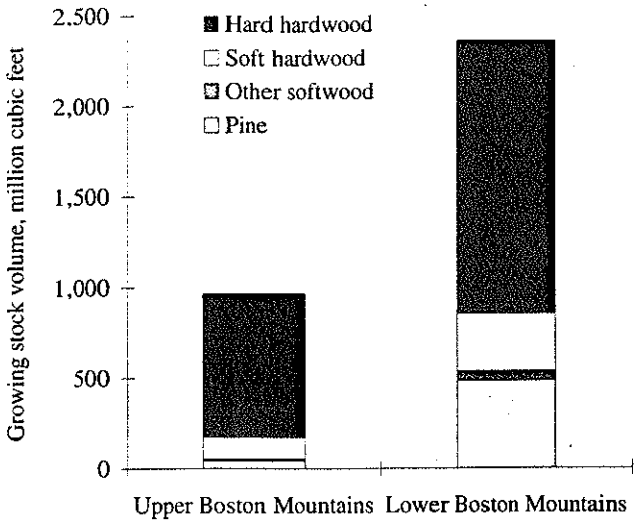


Figure 3.31—Distribution of growing-stock volume in the Boston Mountains by species group and ecological subsection.

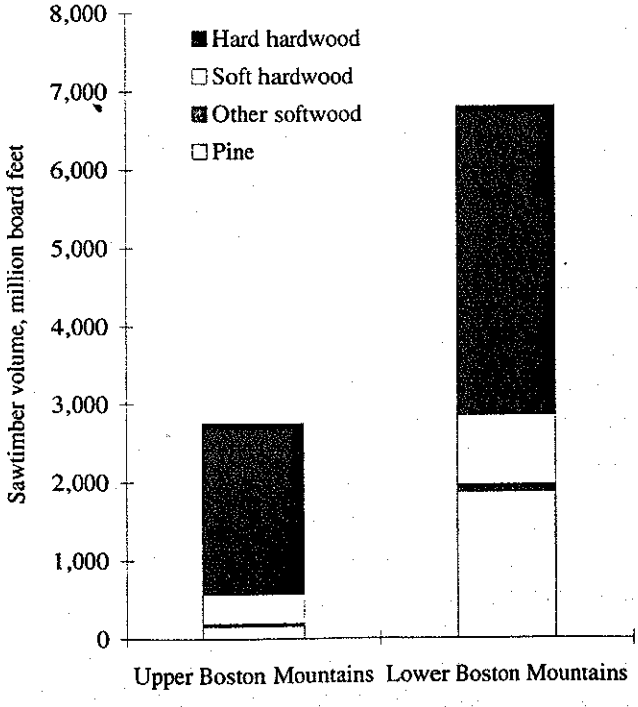


Figure 3.32—Distribution of sawtimber volume in the Boston Mountains by species group and ecological subsection.

percent of the sawtimber board-foot volume in the Lower Boston Mountains.

General Forest Attributes. The average acre of timberland in the Boston Mountains section has 612 live trees, of which 277 are of growing-stock quality. These values are greater than the average for the Assessment area. The 2-in. and 4-in. d.b.h. classes contain 75 percent of the live trees, but only 56 percent of growing-stock trees. Only 33 percent of the trees in these two classes are growing stock, compared to slightly more than 80 percent in the diameter classes 6 in. and larger.

Softwoods account for about 10 percent of the live trees and 18 percent of growing-stock trees, which is approximately equal to and slightly greater than the respective softwood percentages in the Ozark Highlands section. This also indicates an increasing prominence of softwoods in the growing-stock component of the Boston Mountains section.

Slightly more than 70 percent of the land in the Boston Mountains section is either fully stocked or overstocked, a higher percentage than for the Ozark Highlands section. All forest industry land and nearly 90 percent of national forest land are in these two stocking classes; however, less than 50 percent of the land in the "other public" sector is in these classes (fig. 3.33).

The average timberland acre in the Boston Mountains section has a live-tree volume of 1,242 cubic feet, a growing-stock volume of 1,096 cubic feet, a sawtimber cubic volume of 524 cubic feet, and a sawtimber board-foot volume of 3,151 board feet. These values are approximately 25 percent higher than the averages for the Assessment area (refer to table 3.3 for the latter).

The Boston Mountains section appears to have better sites and a higher percent stocking, on average, than the Ozark Highlands. Fifteen percent of the growing-stock volume and 21 percent of the sawtimber cubic foot volume is pine. Hard hardwoods account for 69 percent of the growing-stock volume and 64 percent of the sawtimber cubic-foot volume. These data support the previous observation that pine appears to be slightly more prominent in the Boston Mountains section than in the Ozark Highlands section.

White oak, shortleaf pine, northern red oak, black oak, and post oak have the greatest live-tree and growing-stock volumes in the Boston Mountains section. Together they make up 64 percent of the live-tree volume, 66 percent of the growing-stock volume, and 70

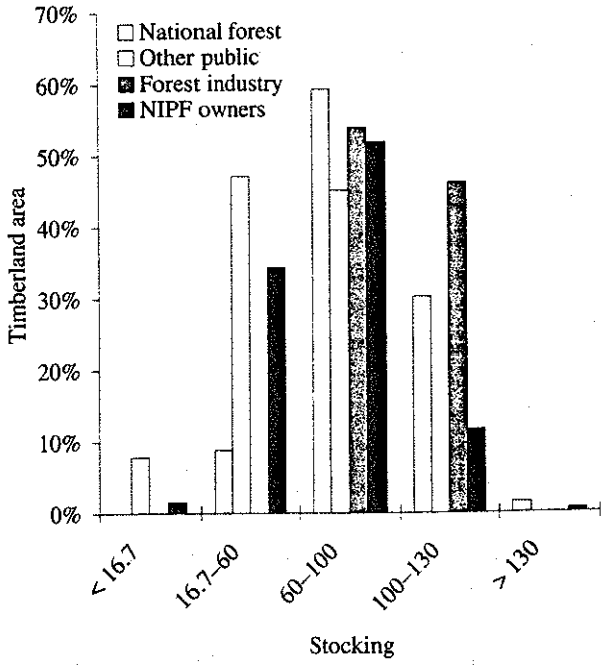


Figure 3.33—Distribution of timberland in the Boston Mountains by stocking class and ownership category.

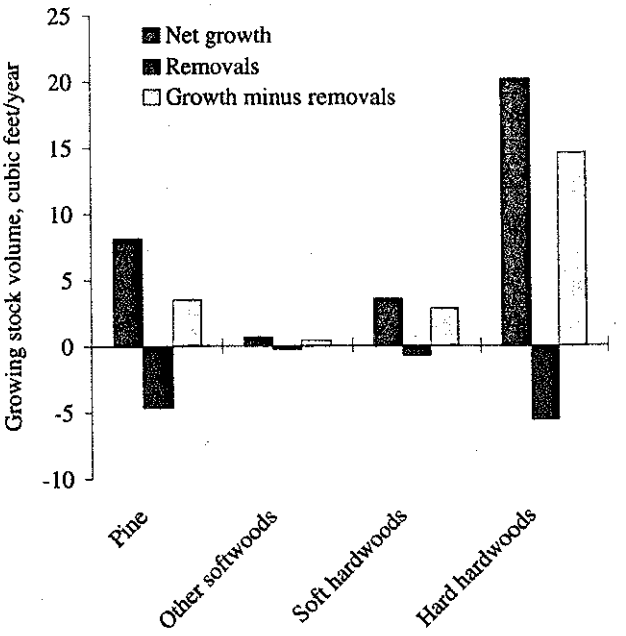


Figure 3.34—Growth, removals, and growth minus removals of growing-stock volume in the Boston Mountains by species group.

percent of the sawtimber board-foot volume in the section. Shortleaf pine displaces white oak as the top-ranking species in sawtimber board-foot volume; together, these two species account for 40 percent of the sawtimber board-foot volume (21 percent and 19 percent, respectively) in the section.

Growth, Removals, and Mortality. Analysis reveals a total annual growth surplus per acre of slightly more than 20 cubic feet in the Boston Mountains section (sum of the surpluses shown in light gray in fig. 3.34). The average annual net growth per acre on timberland in this section is 32.6 cubic feet, of which 62 percent is in the hard hardwoods and 25 percent is in pine. Average annual removals per acre total 11.2 cubic feet, 50 percent of which is hard hardwood removals and 41 percent pine removals. Thus, net growth is nearly three times the removals.

Average annual mortality per acre on timberland in this section is 4.3 cubic feet—slightly more than 11 percent of gross annual growth and less than 50 percent the level of removals. Hardwood mortality is nearly 14 percent of gross hardwood growth, whereas softwood mortality is 5 percent of growth. The highest mortality rate is in soft hardwoods, about 17 percent of gross net annual growth.

Arkansas Valley

General Land Attributes. The Arkansas Valley section, the smallest section in the Assessment area, contains 3.73 million ac. It contains three ecological subsections: the Western Arkansas Valley (1.59 million ac), the Western Arkansas Valley Mountains (664,000 ac), and the Eastern Arkansas Valley (1.47 million ac).

Both Eastern and Western Arkansas Valley subsections have slightly more than 50 percent of their area in timberland (fig. 3.35), but the Western Arkansas Valley Mountains subsection is 93 percent forested. The Western Arkansas Valley Mountains is also the only subsection in this section with any reserved forestland, but the other sections have lands in the "other woodland" category. Ninety-seven percent of the forestland in the Arkansas Valley is commercial timberland.

Virtually all of the Eastern Arkansas Valley subsection is in private ownership—95 percent is NIPF

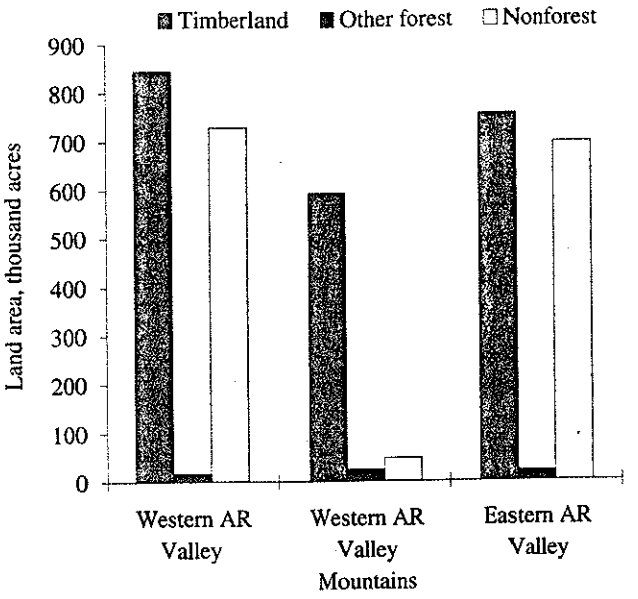


Figure 3.35—Distribution of timberland, other forest land, and nonforest land in the Arkansas Valley section by ecological subsection.

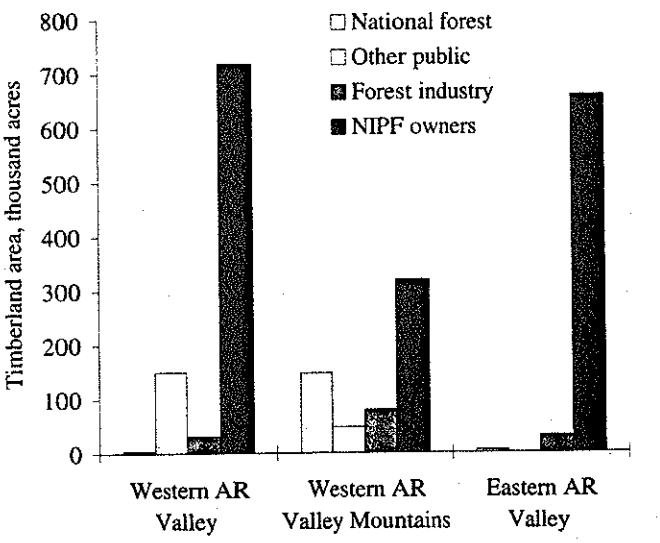


Figure 3.36—Distribution of timberland in the Arkansas Valley section by ownership category and ecological subsection.

holdings. Nearly 33 percent of the Western Arkansas Valley Mountains subsection consists of public lands (fig. 3.36). The Western Arkansas Valley subsection has 17 percent in public lands and 83 percent in private ownership, similar to the average for the Arkansas Valley section as a whole.

Differences in forest types are also prominent (fig. 3.37). In the Western Arkansas Valley, 86 percent of the timberland area is in oak-dominated types. However, in the Eastern Arkansas Valley 76 percent is in oak-dominated types and almost 20 percent is in pine types. Oak-dominated forests cover 70 percent of the Western Arkansas Valley Mountains.

Figures 3.38 and 3.39 provide growing-stock and sawtimber-volume data for this section, which contrasts markedly from the two sections to the north. In the Western Arkansas Valley subsection, hardwoods make up 72 percent of growing-stock volume and 63 percent of the sawtimber board-foot volume on timberland. But hard hardwoods are only 42 percent of the growing-stock volume and 38 percent of the sawtimber volume in this subsection—50 percent less timberland volume in hard hardwoods than in the Boston Mountains or Ozark Highlands.

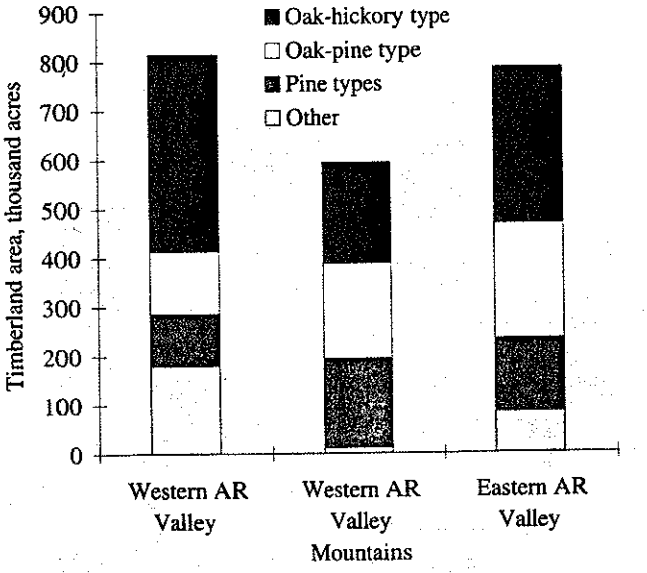


Figure 3.37—Distribution of timberland in the Arkansas Valley section by forest type.

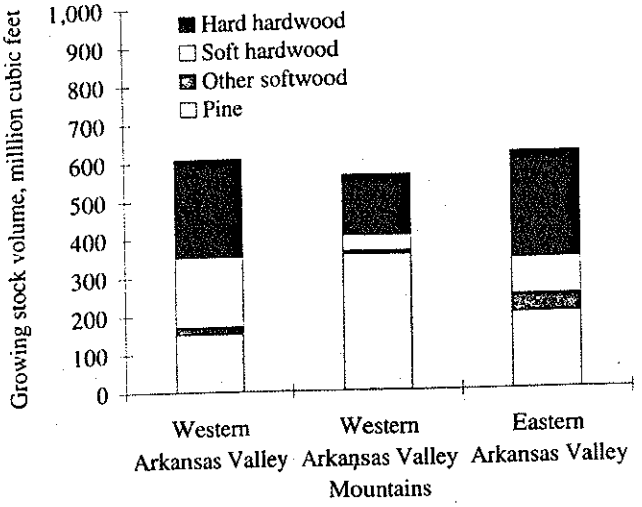


Figure 3.38—Distribution of growing-stock volume in the Arkansas Valley section by species group.

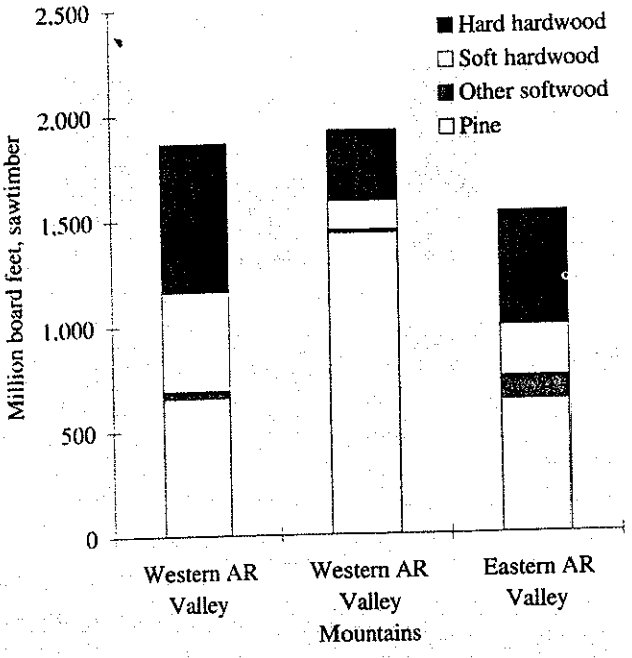


Figure 3.39—Distribution of sawtimber volume in the Arkansas Valley section by species group.

The gain is in softwoods, which are 25 percent of the growing-stock volume and 33 percent of the sawtimber volume in the Western Arkansas Valley subsection. Softwoods are even more prominent in the Eastern Arkansas Valley subsection, where they make up nearly 40 percent of growing-stock volume and nearly 50 percent of sawtimber volume; hard hardwood volume declines to 45 percent of growing-stock volume and 35 percent of sawtimber volume.

Finally, the Western Arkansas Valley Mountains subsection is the first area from north to south in the Assessment area where softwoods consistently show higher volume than hardwoods. About 65 percent of growing-stock volume and 75 percent of sawtimber board-foot volume are in softwoods; hard hardwoods are reduced to 28 percent of the growing-stock volume and 17 percent of sawtimber board-foot volume.

General Forest Attributes. The average acre of timberland in the Arkansas Valley section has 579 live trees, of which 288 are of growing-stock quality. Only 41 percent of the trees in the 2-in. and 4-in. class are growing-stock trees, compared with slightly more than 75 percent of trees 6 in. and larger. Softwoods account for about 29 percent of the live trees and 46 percent of growing-stock trees—much higher percentages than in the Ozark Highlands or Boston Mountains.

Live-tree basal area of the average timberland acre is about 90 square feet, of which nearly three-fourths are in growing-stock. The quadratic mean diameter is 5.2 in. for the average live tree and 6.6 in. for the average growing-stock tree. Growing-stock hardwoods have a slightly larger quadratic mean diameter (6.7 in.) than growing-stock softwoods (6.3 in.).

Slightly less than 66 percent of the timberland in the Arkansas Valley section is either fully stocked or overstocked. As in most other sections, stocking varies markedly with ownership class (fig. 3.40). More than 95 percent of national forest land and 80 percent of forest industry land fall into these two classes. Nonindustrial private forestland is less well stocked, with 62 percent in the moderate- and fully-stocked classes. More than one-third of NIPF timberland is poorly stocked and over half of the "other public" sector is poorly stocked.

The average timberland acre in the Arkansas River Valley section has a live-tree volume of 959 cubic feet, a growing-stock volume of 812 cubic feet, a sawtimber cubic volume of 406 cubic feet, and a sawtimber

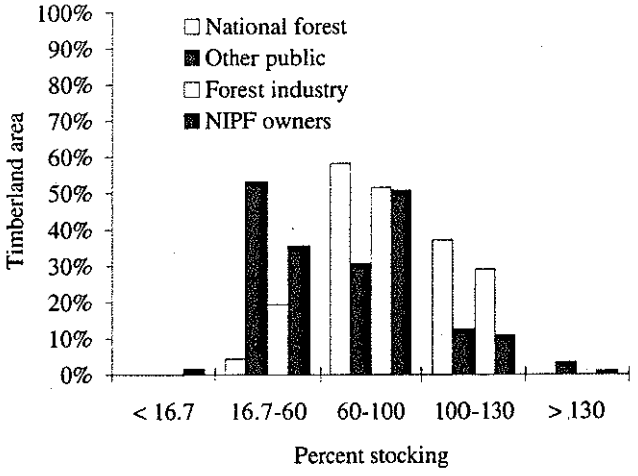


Figure 3.40—Distribution of timberland in the Arkansas Valley section by stocking class and ownership category.

board-foot volume of 2,418 board feet. These values are marginally lower in the live-tree and growing-stock volume categories, and marginally greater in the sawtimber categories, than the averages for the Assessment area (see table 3.3 for the latter).

Significant differences exist among subsections. The Western Arkansas Valley Mountains subsection has growing-stock volumes that are 16 percent greater and sawtimber board-foot volumes 34 percent greater than the section average. In the pine component alone, the Western Arkansas Valley Mountains has 85 percent more growing-stock volume than the section average and nearly double the sawtimber board-foot volume.

The five species with the greatest live-tree and growing-stock volumes on timberland in the Arkansas Valley section are shortleaf pine, post oak, sweetgum, white oak, and eastern red cedar. Together they make up 63 percent of the live-tree volume and 66 percent of the growing-stock volume in the section. For sawtimber board-foot volume, southern red oak replaces eastern red cedar in the top five, which then collectively make up 73 percent of the sawtimber board-foot volume in the section.

Shortleaf pine far exceeds the other species in these rankings; it has more than twice the live-tree volume, three times the growing-stock volume, and more than six times the sawtimber board-foot volume of the second-ranked species, post oak. Shortleaf in total represents 32 percent of the live-tree volume, 37 percent of growing-stock volume, and almost exactly 50 percent of the sawtimber board-foot volume in the section.

Growth, Removals, and Mortality. The Arkansas Valley section shows a total annual growth surplus per acre of 20 cubic feet (sum of the surpluses shown in fig. 3.41). Average annual net growth per acre on timberland in this section is 33.3 cubic feet, of which 48 percent is in the pine component and 47 percent is in the hardwood component. Average annual removals per acre total 13.3 cubic feet, 59 percent of which is in pine and 38 percent in hardwood. Thus, net growth is about two and one-half times the removals.

Average annual mortality per acre on timberland in this section is 5.1 cubic feet—slightly more than 13 percent of gross growth annually and less than 50 percent the level of removals. Hardwood mortality is nearly 20 percent of gross hardwood growth, whereas softwood mortality is about 6 percent of growth. The highest mortality rate is in the soft hardwoods, at 41 percent of gross net annual growth.

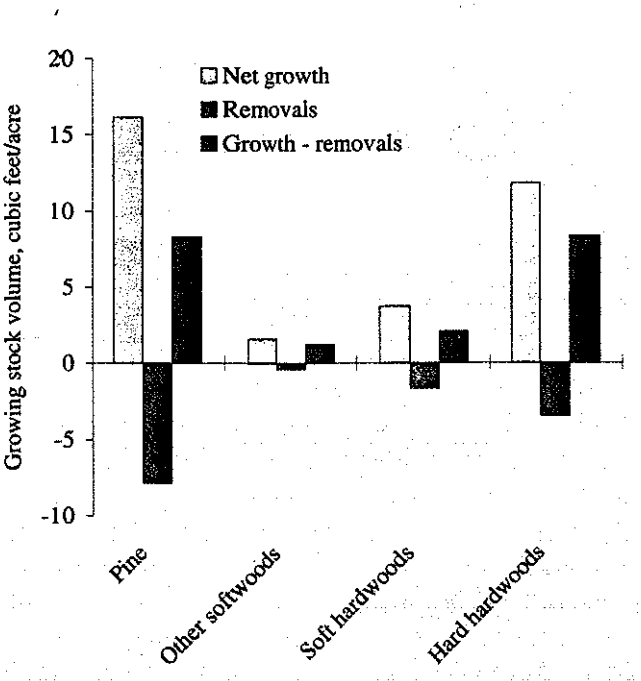


Figure 3.41—Growth, removals, and growth minus removals of growing-stock volume in the Arkansas Valley section by species group.

Ouachita Mountains

General Land Attributes. The Ouachita Mountains section is the second largest in the Assessment area, encompassing a total land area of 6.6 million ac. It contains four ecological subsections: the Fourche Mountains (2.74 million ac), the Western Ouachita Mountains (1.44 million ac), the Athens Piedmont Plateau (889,000 ac), and the Central Ouachita Mountains (1.53 million ac).

The Central subsection is subdivided into two units, one located in Arkansas and the other in Oklahoma. About 85 percent of the Ouachita Mountains are forested; subsections vary from 78 percent to nearly 100 percent forested (fig. 3.42). Slightly more than 97 percent of the total forest land in the Ouachita Mountains is in commercial timberland; subsections vary from 93 percent to 100 percent.

The ownership pattern in the Ouachita Mountains (fig. 3.43) has two attributes unique in the Assessment area. First, nearly 25 percent of the timberland in this section is in national forest ownership. More than 57 percent of the Fourche Mountains subsection is in public ownership, the highest proportion in any subsection of the Assessment area. Second, in the private sector, forest industry owns more land in the Ouachita Mountains than do NIPF owners; of the 71 percent of the section in private ownership, industry owns 51.6 percent. Forest industry timberland ownership varies from 25 percent of the Athens Piedmont Plateau section to 88 percent of the Central Ouachita Mountains subsection.

Forest type differences in the Ouachitas (fig. 3.44) are much less prominent than in the Arkansas Valley. Over the entire section, the proportion of pine forest is slightly greater than 40 percent. The percentage of pine type by subsections varies from 31 percent in the Central Ouachita Mountains to 51 percent in the Athens Plateau. However, oak forest types (which includes the oak-pine type) occupy a larger percentage of timberland than pine types in all subsections except the Athens Plateau.

The growing-stock and sawtimber-volume data clearly show the prominence of pine volume on timberland in the Ouachita Mountains (figs. 3.45 and 3.46). Pine makes up from 63.5 to 71.4 percent of growing-stock volume and from 71 to 81 percent of sawtimber

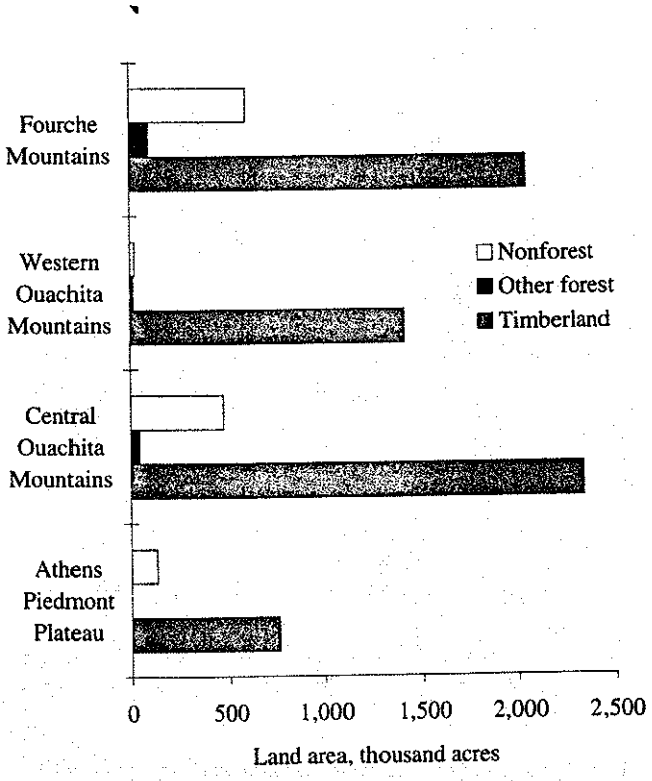


Figure 3.42—Distribution of nonforest land, timberland, and other forest land in the Ouachita Mountains section by ecological subsection.

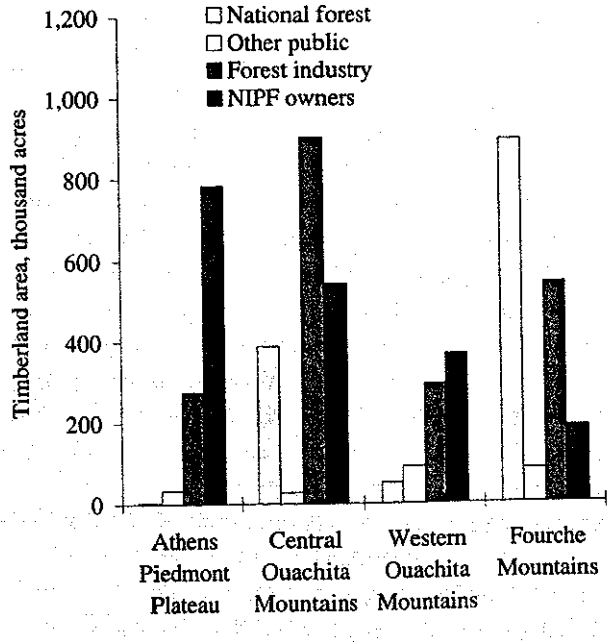


Figure 3.43—Distribution of timberland in the Ouachita Mountains by ecological subsection and ownership category.

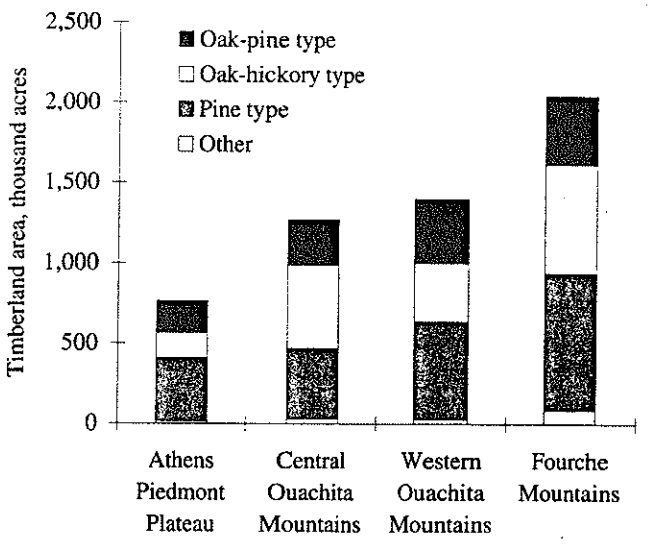


Figure 3.44—Distribution of timberland in the Ouachita Mountains by forest type and ecological subsection.

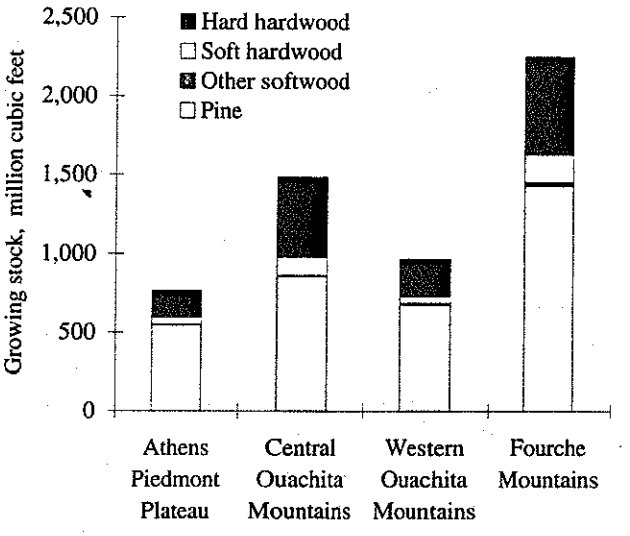


Figure 3.45—Growing-stock volume in the Ouachita Mountains by species group and ecological subsection.

board-foot volume in the five subsections of the Ouachitas. Conversely, hard hardwoods vary from 22 percent to 34 percent of growing-stock volume and from 15 percent to 24 percent of sawtimber board-foot volume, in these subsections.

General Forest Attributes. The average acre of timberland in the Ouachita Mountains section has 665 live trees, of which 363 are of growing-stock quality.

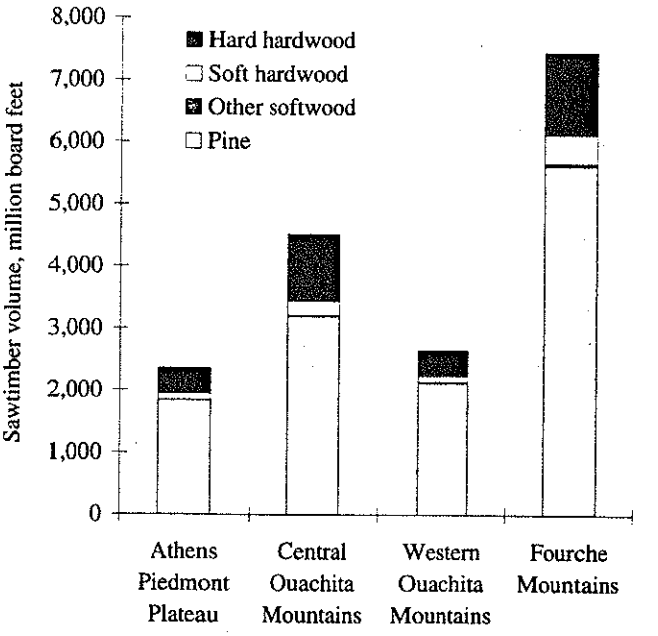


Figure 3.46—Sawtimber volume in the Ouachita Mountains by species group and ecological subsection.

Only 45 percent of the trees in the 2-in. and 4-in. classes are growing-stock trees, compared with slightly more than 83 percent of trees 6 in. and larger. Softwoods account for about 34 percent of the live trees and 52 percent of growing-stock trees—a higher percentage than in any other section, and further evidence of the prominence of pine in the Ouachita Mountains section.

Live-tree basal area of the average timberland acre is about 87 square feet, of which 76 percent is in growing stock. Stocking by ownership category is less variable in the Ouachita Mountains than in the other sections (fig. 3.47). About 66 percent of the timberland in the Ouachita Mountains is either fully stocked or overstocked, ranging from 62 percent in the other public sector to 84 percent on national forest land. As in the Arkansas Valley, the other public and NIPF ownership sectors have at least 33 percent of their timberland in the two poorest stocking classes. These lands are more likely to be poorly stocked than either forest industry timberland (17 percent poorly stocked) or national forest timberland (10 percent poorly stocked).

The average timberland acre in the Ouachita Mountains section has a live-tree volume of 1,104 cubic feet,

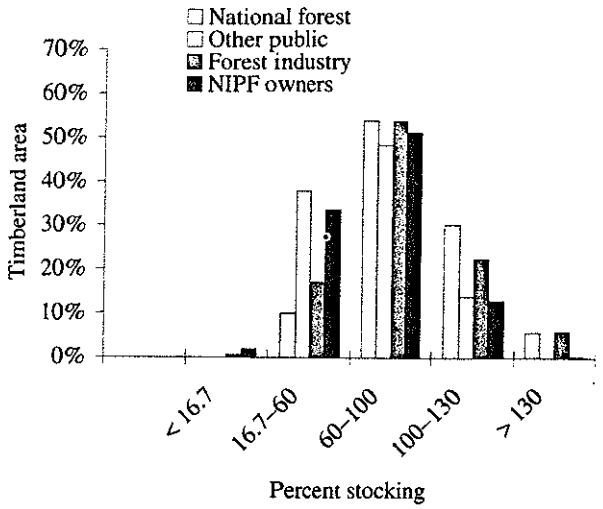


Figure 3.47—Distribution of timberland in the Ouachita Mountains by stocking class and ownership category.

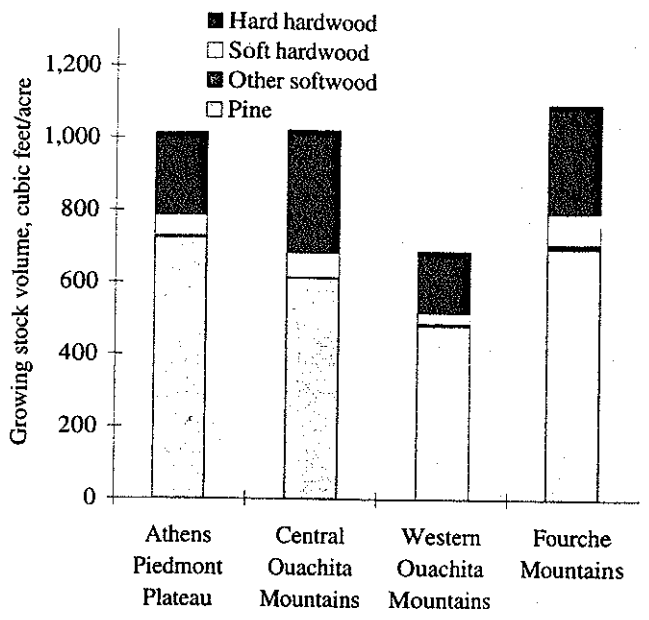


Figure 3.48—Growing-stock volume in the Ouachita Mountains by species group and ecological subsection.

a growing-stock volume of 1,000 cubic feet, a sawtimber cubic volume of 514 cubic feet, and a sawtimber board-foot volume of 3,097 board feet. These values are all greater than the averages for the Assessment area (refer to table 3.3 for the latter). However, volumes by subsection are quite variable (figs. 3.48 and 3.49). Growing-stock volume ranges from slightly less than 700 cubic feet/ac in the Western subsection to slightly more than 1,100 cubic feet/ac in the Fourche Mountains subsection. Three of the subsections—the Central Ouachita Mountains, the Fourche Mountains, and the Athens Piedmont Plateau—have growing-stock volumes in excess of 1,000 cubic feet/ac (fig. 3.48).

Sawtimber board-foot volume (fig. 3.49) ranges from slightly more than 1,500 board feet/ac in the Western Ouachita Mountains subsection to slightly more than 3,600 board feet/ac in the Fourche Mountains subsection. But the Central Ouachita Mountains, the Fourche Mountains, and the Athens Piedmont Plateau all have average sawtimber volumes in excess of 3,000 board feet/ac.

In no other section within the Assessment area is a single species as dominant in volume as shortleaf pine is in the Ouachita Mountains. Shortleaf pine accounts for 46 percent of the live-tree volume, 50 percent of the growing-stock volume, and slightly more than 67 percent of the sawtimber board-foot volume on timberland in the Ouachitas. Furthermore, 56 percent of all

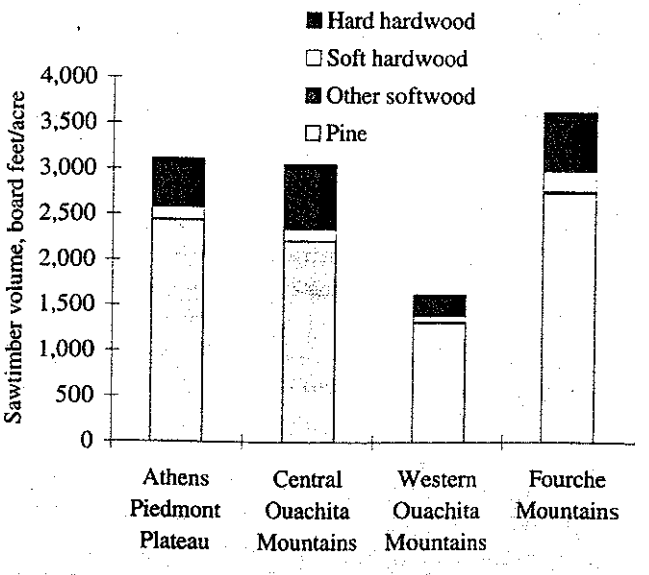


Figure 3.49—Sawtimber volume per acre in the Ouachita Mountains by species group and ecological subsection.

shortleaf pine volume in the Ouachita Mountains is on national forest land.

Growth, Removals, and Mortality. The Ouachita Mountains section shows a total annual growth surplus of 20 cubic feet/ac (sum of the surpluses shown in fig. 3.50). Higher net annual growth and higher annual removals are found here than in any of the other sections in the Assessment area.

Average annual net growth per acre on timberland in this section is slightly more than 50 cubic feet, of which more than 76 percent is in the pine component and 19 percent is in the hard-hardwood component. Average annual removals per acre total 30 cubic feet, 80 percent of which are pine removals and 16 percent of which are hardwood removals. Thus, net growth is about 1.7 times the removals.

Average annual mortality per acre on timberland in this section is 3.8 cubic feet—about 7 percent of gross annual growth and about 17 percent of removals. Hardwood mortality is 12 percent of gross hardwood growth—the lowest figure of any section in the Assessment area. Softwood mortality is about 5 percent of growth. Overall, mortality in the Ouachita Mountains section is fairly low.

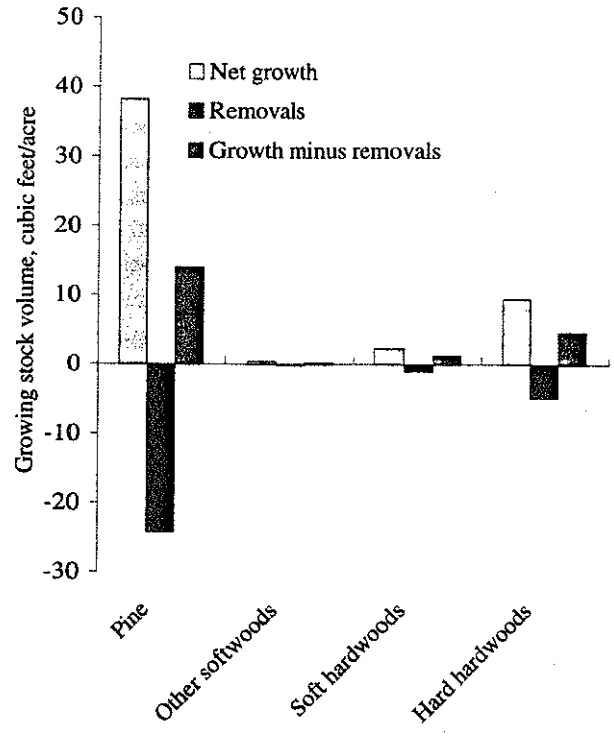


Figure 3.50—Growth, removals, and growth minus removals of growing-stock volume in the Ouachita Mountains by species group.

Implications and Opportunities

There is a significant relationship between forest cover and private land ownership—the larger the percentage of private timberland in a subsection, the smaller the percentage of timberland. Public land management typically involves timely reforestation and constraints on the conversion of forested land to other uses. NIPF owners are under no such limitations and often encounter different pressures concerning forest retention. NIPF management is based strictly on the will of the respective owner. On NIPF lands, owners have few incentives that would encourage long-term retention of forest cover. For example, some NIPF owners convert timberlands to more productive non-forest uses, which would not likely occur on public timberlands.

Vegetation Patterns Based on AVHRR Imagery

The previous section described vegetation of the Ozark-Ouachita Highlands based on FIA data. Other sources of data on regional vegetation exist that may provide different perspectives.

Of primary importance is digital satellite imagery. These images are relatively inexpensive to acquire and can be updated frequently. They provide a relatively high level of spatial detail and reveal patterns of land cover. Satellite and FIA data have complementary strengths and weaknesses.

FIA data are collected manually from a field sample plot with a high level of detail. The number of plots must, therefore, be relatively small and is usually limited to one plot every 3 miles. Plots over a relatively large area (typically the size of one of the sections of the Highlands) must be statistically aggregated to provide meaningful results. Therefore, spatial discrimination of FIA statistics is limited to relatively large areas where many plots can be aggregated. If a few plots of an uncommon vegetation type are tallied, even across a large area, the statistical error on the acreage estimate of that type will be relatively large.

In contrast, when satellite imagery is used, the land surface is completely covered by digital dots, called

pixels, which correspond to individual sample plots of FIA. These pixels typically range in width from 33 feet (10 meters) to 3,300 feet (1 kilometer), depending on the satellite system. Therefore, areas much smaller than a section or subsection can be mapped using satellite imagery.

A disadvantage of satellite data is that few measurements are made at each point. To use these spectral data to map vegetation, the spectral signature (relationships in brightness among the various spectral bands) of points on the ground is compared to known vegetation. The relationships must be statistically characterized and used to infer the vegetation at other places. The accuracy of any classification so derived will vary with intrinsic similarity between vegetation types, time of year of the image, amount of ground-truth data, and other factors. Classifications based on satellite imagery utilize many sample points but have a relatively low level of detail. The FIA data entail relatively few plots but incorporate a high level of detail.

The limiting factor on accuracy of analyses based on the FIA data is the number of plots of a given vegetation type used for a specific analysis. In contrast, the limiting factor on satellite imagery is the reliability of prediction of vegetation types using spectral signatures. Satellite data can provide a good estimate of the acreage of a land cover type within a relatively small area, whereas estimates from FIA data are accurate only at regional and subregional (multi-county) scales. Satellite data should also provide more detailed information on spatial patterns if an accurate discrimination of vegetation types is achieved.

This section on vegetation patterns of the Highlands will concentrate on the most useful types of data from satellite imagery. These include the acreage of specific vegetation types by subsection and spatial patterns of these types, particularly fragment size and distance to nearest forest fragment.

Each State in the Highlands has developed or is developing a vegetation map under the National Gap Analysis Project (GAP), led by the U.S. Geological Survey, Biological Resources Division. These maps are based on Landsat Thematic Mapper imagery and show a relatively high level of detail (pixel size of 30 meters or 98 feet). Unfortunately, at of the time of this analysis, the GAP map was completed only for Arkansas.

Data Sources and Methods of Analysis

In the absence of a Highlands-wide GAP map, a national map based on AVHRR satellite imagery (USDA FS SFES 1992) was used as the source for this analysis. The National Oceanic and Atmospheric Administration (NOAA) collects AVHRR data for land cover characterization.

The pixel size is relatively large (1 kilometer or about 3,300 feet) and only four bands of data are collected, but worldwide, frequent coverage is available. The primary problem with using AVHRR data is the large pixel size. The spectral signature of the pixel is affected by all of the ground cover over 247 ac. Several vegetation types and other features can occur within an area this size. Therefore, errors in classification are bound to occur.

For this analysis, sections and subsections of the Ozark-Ouachita Highlands were overlaid on the AVHRR-based vegetation map to compute acreage and spatial statistics by subsection. This map uses the FIA classification system and so provides information on comparable vegetation types. Neither source classifies vegetation other than forest; therefore, prairie, improved grassland, shrubland, and open woodland (savanna) are not distinguished.

In addition to computing acreage of forest types by subsection, the program FRAGSTATS (McGarigal and Marks 1995) was used to compute mean forest-patch size, variation in patch size, and mean distance between forest patches within each subsection. To register as a forest patch, at least one pixel (247 ac) must contain sufficient tree cover to be classified as forest. A forest patch as defined in this analysis is a substantially forested area of at least 247 ac that is separated from other forest patches by a substantially nonforested belt at least 3,300 feet wide.

Patch size coefficient of variation and mean distance between patches were also calculated. Patch size coefficient of variation is a measure of the variability in patch size. When this number is high, it indicates that the patches range in size from very large to very small; when this number is relatively small, most patches are about the same size. Mean distance between forest patches is a measure of the dispersion across the landscape. For instance, there could be few patches widely spread apart or close together or many patches widely spread apart or close together. Generally, as

mean patch size decreases, mean distance between patches increases.

Comparison of AVHRR and FIA Acres

The AVHRR-based estimate of the total acreage of the Assessment area is 9 percent larger than the FIA-based estimate (table 3.7). The maximum discrepancies for subsections are 29 percent for the Western Arkansas Valley Mountains subsection (231Gb), 27 percent for the Springfield Plateau subsection (222An), and 27 percent for the Western Arkansas Valley subsection (231Gc). However, the overall estimates of forested acreage, which both sources of data

Table 3.7—Total area, forest area, and percent of area forested by subsection, based on AVHRR and FIA data and showing the different results obtained from the two sources

	Total area			Forest area			Percent Forest		
Subsection	AVHRR	FIA	Difference	AVHRR	FIA	Difference	AVHRR	FIA	Difference
	- - Thousand acres - -		*Percent*	*- - Thousand acres - -*		*Percent*	*- Thousand acres -*		*Percent*
222Aa	1,148.5	1,092.1	4.9	862.6	750.2	13.0	75.1	68.7	6.4
222Ab	6,830.5	6,338.7	7.2	2,893.9	3,099.1	6.6	42.4	48.9	6.5
222Ac	1,633.1	1,399.2	14.3	1,256.3	855.3	31.9	76.9	61.1	15.8
222Ad	1,122.4	1,087.5	3.1	744.5	654.3	12.1	66.3	60.2	6.2
222Ae	1,178.4	1,168.1	0.9	1,069.2	891.4	16.6	90.7	76.3	14.4
222Af	1,498.4	1,563.3	4.1	1,444.1	1,322.0	8.5	96.4	84.6	11.8
222Ag	3,764.7	3,583.7	4.8	2,142.9	2,342.8	8.5	56.9	65.4	8.5
222Ah	435.2	434.0	0.3	125.0	264.2	52.7	28.7	60.9	32.1
222Al	876.5	860.7	1.8	660.8	677.1	2.4	75.4	78.7	3.3
222Am	3,502.2	3,103.1	11.4	234.0	641.8	63.5	6.7	20.7	14.0
222An	3,086.3	2,240.4	27.4	1,292.1	1,403.6	7.9	41.9	62.6	20.8
Total	25,076.3	22,870.8	8.8	12,725.4	12,901.8	1.4	50.7	56.4	5.7
231Ga	1,505.1	1,470.1	2.3	599.0	774.3	22.6	39.8	52.7	12.9
231Gb	939.2	664.1	29.3	724.5	616.8	14.9	77.1	92.9	15.7
231Gc	2,170.3	1,590.9	26.7	571.6	862.2	33.7	26.3	54.2	27.9
Total	4,614.7	3,725.1	19.3	1,895.1	2,253.3	15.9	41.1	60.5	19.4
M222Aa	1,081.6	1,129.7	4.3	928.9	904.9	2.6	85.9	80.1	5.8
M222Ab	3,270.7	2,960.3	9.5	2,135.5	2,276.8	6.2	65.3	76.9	11.6
Total	4,352.3	4,090.0	6.0	3,064.4	3,181.7	3.7	70.4	77.8	7.4
M231Aa	2,895.3	2,740.8	5.3	2,269.2	2,147.3	5.4	78.4	78.3	0.0
M231Ab	1,665.7	1,443.2	13.4	1,521.9	1,421.8	6.6	91.4	98.5	7.2
M231Ac	1,626.2	1,526.6	6.1	1,357.6	1,292.4	4.8	83.5	84.7	1.2
M231Ad	901.4	889.5	1.3	817.9	756.4	7.5	90.7	85.0	5.7
Total	7,088.7	6,600.1	6.9	5,966.6	5,617.9	5.8	84.2	85.1	0.9
Total	41,131.9	37,286.0	9.4	23,651.4	23,954.7	1.3	57.5	64.2	6.7

AVHRR = Advanced Very High Resolution Radiometer, FIA = Forest Inventory and Analysis.

emphasize, differ by only 1.3 percent, with maximum discrepancies of 64 percent for the Springfield Plain subsection (222Am) and 54 percent for the Elk River Hills subsection (222Ah). These two subsections have the least area of forest in the Assessment area.

The large differences may illustrate the problems with statistical extrapolation based on having only a few FIA plots. The difference in percentage of area forested by subsection is 7 percent. Maximum discrepancies are 32 percent for Elk River Hills and 28 percent for the Western Arkansas Valley (231Gc). These estimates are closely related given that the methods are dramatically different. They should reinforce reliance on both sets of data.

Forest Type Coverage

Loblolly-Shortleaf Pine Type. This type covers 4 million ac or almost 10 percent of the Assessment area (table 3.8). The largest acreage and percentage of this cover type occur in the subsections of the Ouachita Mountains, where it occupies 0.5 to 1 million ac and from 66 percent to 33 percent of each subsection's area. By contrast, the type does not occur in the Elk River Hills and only occurs on 247 ac (one pixel) in the Springfield Plain.

Oak-Pine Type. This type is the second most extensive within the Assessment area, covering 4.4 million ac or nearly 11 percent of the Highlands (table 3.8). The greatest acreage of this type occurs within the Fourche Mountains (M231Aa, 658,000 ac) and Western Ouachita Mountains (M231Ab, 440,000 ac) subsections, but its maximum percent cover is in the Western Arkansas Valley Mountains (376,000 ac, 40 percent). Oak-pine covers a mere 0.1 percent of the Springfield Plain subsection.

Oak-Hickory Type. This forest type is usually described as the characteristic vegetation cover of the northern two-thirds of the Interior Highlands (Ozark Highlands and Boston Mountains sections). As measured by AVHRR data, oak-hickory forest is the most extensive forest type in the Highlands, covering almost 15 million ac or almost 36 percent of the area (table 3.8). Oak-hickory cover is the most prevalent cover type in the Assessment area, exceeded by other types only in the Western Arkansas Valley Mountains and in three of the four subsections of the Ouachita Mountains.

The Central Plateau subsection (222Ab) has the greatest area of oak-hickory type (2.1 million ac) of any subsection, followed by 1.7 million ac in the Lower Boston Mountains (M222Ab). The greatest proportion of oak-hickory is 84 percent of the total cover in the Current River Hills (222Af) subsection and 76 percent in the Upper Boston Mountains (M222Aa). The lowest coverage of oak-hickory type (4.9 percent) occurs in the Springfield Plain, where only 6.7 percent of the landscape is forested.

Oak-Gum-Cypress Type. This swamp forest type is the least common in the Highlands and occupies only 164,000 ac or 0.4 percent of the area (table 3.8). The Western Arkansas Valley subsection has the highest acreage (35,000 ac) and highest percentage (1.6 percent) of area occupied by oak-gum-cypress forest. Oak-gum-cypress covers 26,000 ac in the Fourche Mountains subsection and 24,000 ac in the White River Hills subsection. It covers 1 percent of the Central Ouachita Mountains (M231Ac) and Athens Piedmont Plateau (M231Ad) subsections.

Elm-Ash-Cottonwood Type. This riverfront forest type covers only 360,000 ac (0.9 percent of the total area) within the Highlands (table 3.8). It occurs only within the Ozark Highlands section, where the largest area and largest percentage of area—148,000 ac, 9.1 percent—are within the Osage River Hills subsection (222Ac).

Forest Patch Size and Distribution Within Subsections

Comparing the Springfield Plain subsection to the Current River Hills subsection (222Am and 222Af, respectively) reveals extremes of forest patchiness (table 3.9). The Springfield Plain has many forest patches and a mean patch size of only about 900 ac, a high variation in patch size, and a high mean distance between patches. In contrast, the Current River Hills subsection has few patches, a low mean distance between patches, and a mean patch size of 481,000 ac. In many of these statistics, these two subsections are near or at the extreme values for the region. The exceptions are that four subsections have patches closer together than the Current River Hills. Tables 3.8 and 3.9 provide forest cover and forest area and patch statistics, respectively, for each subsection. A brief overview is presented here.

Table 3.8—Vegetation cover of the Assessment area (based on AVHRR data), showing thousands of acres and percent representation in each subsection of five forest cover types, nonforested land, and water

Sub-section[a]	Loblolly-shortleaf		Oak-pine		Oak-hickory		Oak-gum cypress		Elm-ash-cottonwood		Nonforested		Water		Total
	k acres	*%*	*k acres*	*%*	*k acres*	*%*	*k acres*	*%*	*k acres*	*%*	*k acres*	*%*	*k acres*	*%*	*k acres*
Ozark Highlands Section															
222Aa	14.8	1.3	46.5	4.0	788.5	68.7	0	0	12.8	1.1	285.9	24.9	0	0	1,148.5
222Ab	78.8	1.2	627.4	9.2	2,119.4	31.0	13.6	0.2	54.6	0.8	3,931.2	57.6	5.4	0.1	6,830.5
222Ac	3.2	0.2	72.9	4.5	1,032.2	63.2	0	0	148.0	9.1	358.8	22.0	18.0	1.1	1,633.1
222Ad	26.2	2.3	50.2	4.5	648.2	57.7	0	0	20.0	1.8	377.8	33.7	0	0	1,122.3
222Ae	13.1	1.1	186.3	15.8	864.4	73.3	0	0	5.4	0.5	109.2	9.3	0	0	1,178.4
222Af	16.8	1.1	151.7	10.1	1,259.7	84.1	0	0	15.8	1.1	54.4	3.6	0	0	1,498.4
222Ag	113.7	3.0	799.4	21.2	1,205.6	32.0	23.5	0.6	0.7	0	1,462.1	38.8	159.6	4.2	3,764.6
222Ah	0	0	17.1	3.9	107.7	24.8	0.2	0.1	0	0	303.9	69.8	6.2	1.4	435.2
222Al	3.0	0.3	81.1	9.2	528.1	60.2	0	0	48.7	5.6	193.7	22.1	22.0	2.5	876.5
222Am	0.2	0	4.7	0.1	170.0	4.9	4.9	0.1	54.1	1.5	3,209.6	91.6	58.6	1.7	3,502.2
222An	26.7	0.9	183.8	6.0	1,071.7	34.7	9.9	0.3	0	0	1,695.4	54.9	98.8	3.2	3,086.3
Total	296.5	1.2	2,221.1	8.8	9,795.5	39.1	52.1	0.2	360.1	1.4	11,982.0	47.8	368.6	1.7	25,076
Arkansas Valley Section															
231Ga	72.9	4.8	28.7	1.9	493.7	32.8	3.7	0.2	0	0	854.0	56.7	52.1	3.5	1,505.1
231Gb	251.8	26.8	376.1	40.0	93.1	9.9	3.4	0.4	0	0	208.3	22.2	6.4	0.7	939.2
231Gc	100.3	4.6	211.5	9.7	224.6	10.3	35.1	1.6	0	0	1,495.2	68.9	103.5	4.8	2,170.3
Total	425	9.2	616.3	13.3	811.4	17.6	42.2	0.9	0	0	2,557.5	55.4	162	3.5	4,614.6
Boston Mountains Section															
M222Aa	5.9	0.5	99.1	9.2	823.8	76.2	0	0	0	0	152.7	14.1	0	0	1,081.6
M222Ab	246.1	7.5	196.9	6.0	1,676.6	51.3	15.8	0.5	0	0	1,017.3	31.1	117.9	3.6	3,270.7
Total	252	5.8	296	6.8	2,500.4	57.4	15.8	0.4	0	0	1,170	26.9	117.9	2.7	4,352.3
Ouachita Mountains Section															
M231Aa	1,074.7	37.1	658.3	22.7	510.5	17.6	25.7	0.9	0	0	580.7	20.1	45.5	1.6	2,895.3
M231Ab	843.4	50.6	440.3	26.4	235.0	14.1	3.2	0.2	0	0	111.4	6.7	32.4	1.9	1,665.7
M231Ac	535.0	32.9	143.6	8.8	663.0	40.8	16.1	1.0	0	0	116.4	7.2	152.2	9.4	1,626.2
M231Ad	599.2	66.5	50.7	5.6	159.4	17.7	8.6	1.0	0	0	35.8	4.0	47.7	5.3	901.4
Total	3,052.3	43.1	1,292.9	18.2	1,567.9	22.1	53.6	0.8	0	0	844.3	11.9	277.8	3.9	7,088.6
Assessment area	4,025.8	9.5	4,426.3	10.8	14,675.2	35.7	163.7	0.4	360.1	0.9	16,553.8	40.2	926.3	2.2	41,131.9

AVHRR = Advanced Very High Resolution Radiometer; k = thousand.
[a] See figure 1.1 for map of sections and subsections.

222Aa—St. Francis Knobs and Basins. Oak-Hickory forest dominates this subsection (789,000 ac, 69 percent). Other forest types make up 6.4 percent of the area. All patch statistics are intermediate in the range presented for the Assessment area.

222Ab—Central Plateau. This subsection has a relatively low forest cover dominated by oak-hickory forests (2.1 million ac, 31 percent). In addition, oak-pine forest covers 627,000 ac (9.2 percent). It has many patches, and the patch-size variance is high.

222Ac—Osage River Hills. The Osage River Hills are dominated by oak-hickory forest (1 million ac, 63 percent) with a high occurrence of elm-ash-cotton-wood (148,000 ac, 9.1 percent). All patch statistics are intermediate except patches are close together.

222Ad—Gasconade River Hills. Oak-hickory forest dominates this subsection (648,000 ac, 58 percent). All patch statistics are intermediate.

222Ae—Meramac River Hills. The Meramec River Hills are dominated by oak-hickory forest

Table 3.9—Forest area, mean forest patch size, variation in patch size, and mean distance between forest patches, for each subsection, based on AVHRR data

Subsection[a]	Total area	Forest area		Mean forest patch size	Patch size coefficient of variation	Mean distance between patches
	-- *Thousand acres* --		*Percent*	*k acres*		*Feet*
			Ozark Highlands			
222Aa	1,148	862	75.11	66.33	344.26	4,261.65
222Ab	6,828	2,893	42.37	6.82	708.04	4,753.15
222Ac	1,632	1,256	76.93	48.30	486.83	3,407.02
222Ad	1,122	744	66.34	14.88	630.23	4,299.08
222Ae	1,178	1,069	90.73	178.13	223.30	3,280.84
222Af	1,498	1,443	96.37	481.12	141.28	3,733.83
222Ag	3,763	2,142	56.92	15.19	1,118.53	4,413.75
222Ah	435	125	28.73	1.92	346.43	4,229.36
222Al	876	660	75.39	47.18	356.06	4,800.62
222Am	3,501	234	6.68	0.90	372.95	6,457.05
222An	3,085	1,292	41.87	5.79	513.28	4,788.35
			Arkansas Valley			
231Ga	1,504	599	39.80	7.13	417.09	4,526.90
231Gb	939	724	77.14	65.84	175.78	4,439.96
231Gc	2,169	571	26.33	3.17	570.07	5,218.37
			Boston Mountains			
M222Aa	1,081	928	85.88	116.06	263.29	3,690.94
M222Ab	3,269	2,135	65.29	15.14	1,069.37	5,161.22
			Ouachita Mountains			
M231Aa	2,894	2,268	78.37	40.50	723.54	4,308.53
M231Ab	1,665	1,521	91.37	69.15	454.98	3,825.20
M231Ac	1,626	1,357	83.48	84.81	316.43	5,659.68
M231Ad	901	818	90.73	204.39	172.86	3,280.84
Total	41,131	23,641	57.48			

AVHRR = Advanced Very High Resolution Radiometer; k = thousand.
[a] See fig. 1.1 for map of sections and subsections.

(864,000 ac, 73 percent). There are a few large patches of similar size and very close together.

222Af—Current River Hills. Oak-hickory forest dominates this subsection (1.3 million ac, 84 percent), with significant additional coverage by oak-pine forest (152,000 ac, 10 percent). There are a few very large patches close together.

222Ag—White River Hills. The White River Hills are co-dominated by oak-hickory forest (1.2 million ac, 32 percent) and oak-pine forest (799,000 ac, 21 percent). There are many forest patches of intermediate size and distribution.

222Ah—Elk River Hills. Forests are dominated by the oak-hickory type (108,000 ac, 25 percent of the area), but forest cover as a whole occupies only 29 percent of the subsection. Patches are small, on average, but have a high variability in size.

222Al—Black River Ozark Border. This subsection is dominated by oak-hickory forest (528,000 ac, 60 percent), with substantial coverage by oak-pine forest (81,000 ac, 9.2 percent). Elm-ash-cottonwood forest covers an additional 49,000 ac (5.6 percent). Patch characteristics are all intermediate.

222Am—Springfield Plain. This subsection is substantially nonforested, with no forest type exceeding 5 percent. Oak-hickory is the most prominent forest type (170,000 ac, 4.9 percent). There are many very small patches on average but with a high variability in size and spread far apart.

222An—Springfield Plateau. The subsection has relatively low forest cover, dominated by oak-hickory (1.1 million ac, 35 percent). In addition, oak-pine forest covers 184,000 ac (6.0 percent). There are many intermediate-sized patches with little variability in size.

231Ga—Eastern Arkansas Valley. The subsection has relatively low forest cover, dominated by the oak-hickory type (494,000 ac, 33 percent). All forest patch statistics are intermediate.

231Gb—Western Arkansas Valley Mountains. Although this subsection is co-dominated by oak-pine forest (376,000 ac, 40 percent) and loblolly-shortleaf pine forest (252,000 ac, 27 percent), oak-hickory forest also covers a substantial acreage (93,000 ac, 9.9 percent). There are a few patches with an intermediate mean but with a high variability in size.

231Gc—Western Arkansas Valley. The subsection has relatively low forest cover, co-dominated by oak-hickory (225,000 ac, 10 percent) and oak-pine forest (212,000 ac, 9.7 percent). There are many patches with a low to average size but with a high variability in size spaced far apart.

M222Aa—Upper Boston Mountains. This subsection is dominated by oak-hickory forest (824,00 ac, 76 percent) with a substantial coverage of oak-pine forest (99,000 ac, 9.2 percent). There are a relatively few but very large forest patches of similar size spaced close together.

M222Ab—Lower Boston Mountains. Dominated by oak-hickory forest (1.7 million ac, 51 percent), this subsection also has considerable coverage by loblolly-shortleaf pine forest (246,000 ac, 8 percent) and oak-pine forest (197,000 ac, 6.0 percent). All forest patch statistics are intermediate.

M231Aa—Fourche Mountains. This subsection is co-dominated by loblolly-shortleaf pine forest (1.1 million ac, 37 percent) and oak-pine forest (658,000 ac, 23 percent), but oak-hickory forest also covers a substantial area (511,000 ac, 18 percent). All forest patch statistics are intermediate.

M231Ab—Western Ouachita Mountains. Co-dominated by loblolly-shortleaf pine forest (843,000 ac, 51 percent) and oak-pine forest (440,000 ac, 26 percent), this subsection also has a substantial amount of oak-hickory forest (235,000 ac, 14 percent). All forest patch characteristics are intermediate.

M231Ac—Central Ouachita Mountains. Co-dominated by oak-hickory forest (663,000 ac, 41 percent) and loblolly shortleaf pine forest (535,000 ac, 33 percent), this subsection also has about 144,000 ac of oak-pine forest cover (8.8 percent). Patches are large, with little size variation, and spaced relatively far apart.

M231Ad—Athens Piedmont Plateau. This subsection is dominated by loblolly-shortleaf pine forest (599,000 ac, 67 percent), but oak-hickory forest covers significant acreage (159,000 ac, 18 percent). Oak-pine forest also covers an additional 51,000 ac (5.6 percent). There are a few very large patches, similar in size and spaced close together.

Trends in Vegetation Cover

Previous sections of this report have addressed current (or recent) vegetation cover. As outlined in the questions at the beginning of this chapter, the Terrestrial Team also sought to analyze changes in vegetation conditions over time. Although data to address these questions are limited, the results of surveys by the FIA units of the research branch of the USDA Forest Service show interesting trends in the Highlands since the 1940's in Missouri and the 1950's in Arkansas and Oklahoma.

Data Sources and Methods of Analysis

The FIA data used earlier to highlight current conditions by ecological section and subsection could not be used to consider historical trends in forests over time within the Assessment area. Sorting the plots by their respective ecological sections and subsections requires

that data be available in computer files. Unfortunately, old FIA data are not computerized; calculations before the 1970's were done by hand. Therefore, the analysis of trends will be based on the six multi-county FIA regions in the Assessment area, which are shown in figure 3.3.

Forest Survey measurements of these six regions were not conducted in the same calendar year. Thus, for comparative purposes, each measurement was assigned to the decade or decennial (10-year) interval in which it was conducted. FIA region, year measured, decennial interval, and sources are shown in table 3.2. Trends were analyzed by comparing common variables in the Forest Survey reports from one measurement period to the next from the 1940's to the 1990's.

This approach is incomplete because several gaps in the data exist. For example, the Arkansas and Oklahoma regions have no survey data in the 1940's; conversely, the Missouri data have gaps in the 1960's and 1990's. Nevertheless, these are the most quantitative data available on trends over time. Data for all six regions are available for three periods—the 1950's, 1970's, and 1980's—allowing the Terrestrial Team to examine trends during the period of the 1950's through the 1980's.

Patterns and Trends

Area by Land Classes

The total land area of the FIA regions is relatively constant over time for all regions (fig. 3.51). The exception is Oklahoma, where region area was relatively unstable between the 1960's and 1980's because the Forest Survey included different counties in these surveys. These changes were due to questions about the natural limit of commercial forest land in the post oak belt of eastern Oklahoma. Minor variations in acreage for the other regions are due to changes in the process used by the Bureau of the Census to estimate county area.

The amount of forested land area has declined over time. In each of the six regions, the total forest area in the last decennial interval was less than four decades previous (fig. 3.52). From the 1940's to the 1980's in Missouri, forest area declined from 10.22 million ac to 8.78 million ac—a loss of 1.44 million ac (a 14.1 percent

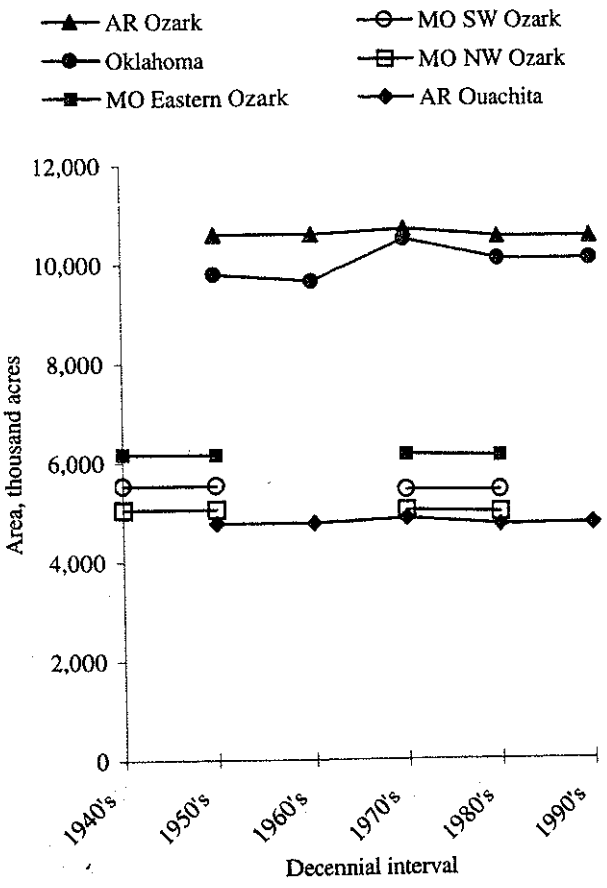


Figure 3.51—Total land area by FIA region, 1940's to 1990's.

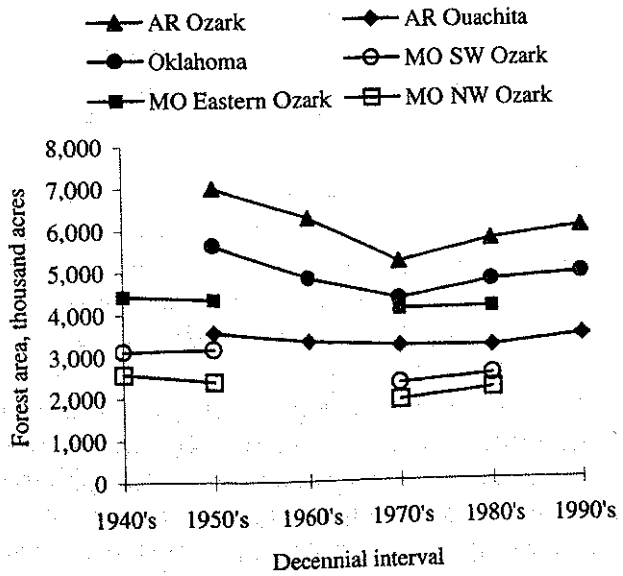


Figure 3.52—Total forest area by FIA region, 1940's to 1990's.

decline from the 1940's forest area). Similarly, from the 1950's to the 1990's in Arkansas and Oklahoma, forest area declined from 16.35 million ac to 15.23 million ac—a decline of 1.12 million ac (a 6.9 percent reduction from the 1950's forest area).

Forest area reached a four-decade minimum in the 1970's in five of the six regions (fig. 3.52). However, some regions lost a larger proportion of forest than did others. For example, forested area in the Arkansas Ozarks declined from 66.2 percent in the 1950's to 48.6 percent forested in the 1970's—a loss of nearly 2 million ac of forest land during that period. The loss of forest area from the 1950's to 1970's varied from 2.5 percent in the Missouri Eastern Ozarks to 17.5 percent in both Oklahoma and the Arkansas Ozarks.

Since the 1970's, forest area has increased in five of the six regions, in some instances dramatically. Between the 1970's and 1980's, the only region to lose forest area was the Missouri Eastern Ozarks, which lost 1.9 percent (134,000 ac). Gains in the other five regions varied from 1.2 percent in the Missouri Southwestern Ozarks to 10.9 percent in Oklahoma. When all six regions were combined, the net gain in forest area from the 1970's to the 1980's was slightly more than 1.89 million ac, or about 4.5 percent. Moreover, this trend of increasing forest area continued from the 1980's to the 1990's in Arkansas and Oklahoma. Forest area in the three regions increased 631,000 ac (5.8 percent).

Distribution by Ownership

Three of the six regions—the Arkansas Ouachitas, Arkansas Ozarks, and Missouri Eastern Ozarks—currently have more than 1 million ac in public forest area (fig. 3.53). From the 1970's to the 1980's, public forest ownership increased by approximately 289,000 ac. Total forest ownership, however, increased by 1.39 million ac. Therefore, the proportion of land in public ownership was fairly constant from the 1970's to 1980's. Overall, the area of public forest is relatively stable.

Private forest ownership is more variable over time, with the largest variations appearing in the Arkansas Ozarks and Oklahoma regions (fig. 3.54). Privately owned forest area reached a minimum in the 1970's, but trends show increases since then in most of the regions.

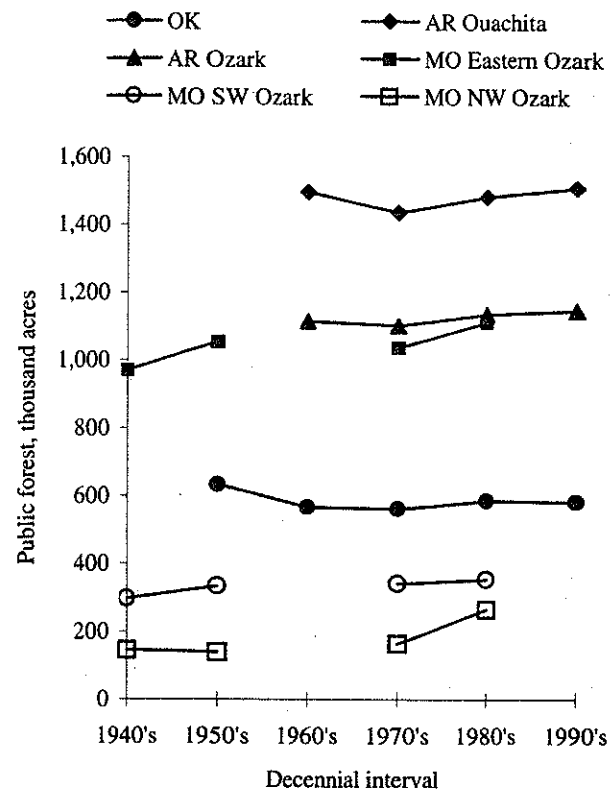


Figure 3.53—Total public forest area by FIA region, 1940's to 1990's.

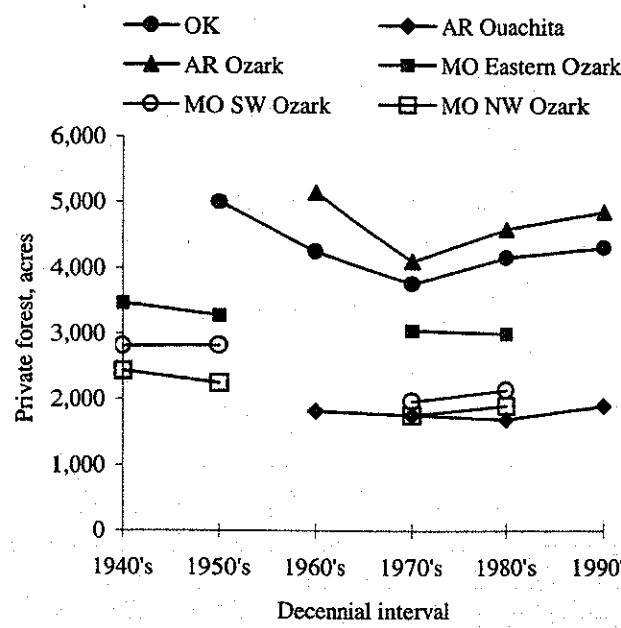


Figure 3.54—Total private forest area by FIA region, 1940's to 1990's.

Distribution by Size Class

The area occupied by sawtimber stands has increased dramatically over time in all six regions. Every region has shown increases in the amount of area in sawtimber-sized trees (fig. 3.55) and in the percentage of forest area occupied by sawtimber-sized trees (fig. 3.56). Between the 1970's and 1980's, total forest area increased by 1.39 million ac (6.5 percent), but forest area in sawtimber-sized trees increased by 2.08 million ac (34.4 percent).

From the 1940's to the 1980's, Missouri forests increased sawtimber area from 10 percent to 46 percent. From the 1950's to the 1990's, Arkansas and Oklahoma forests increased sawtimber area from 17 percent to 37 percent. In the most recent decennial interval, five of the six regions have more than 33 percent of their forest area in sawtimber. The exception is Oklahoma, with 31 percent sawtimber area.

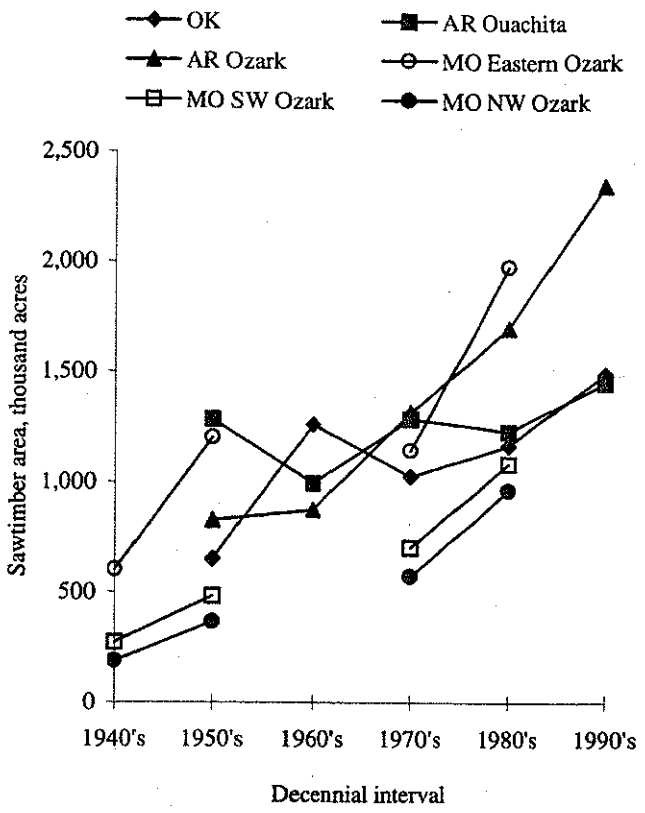


Figure 3.55—Commercial forest area occupied by sawtimber stands by FIA region, 1940's to 1990's.

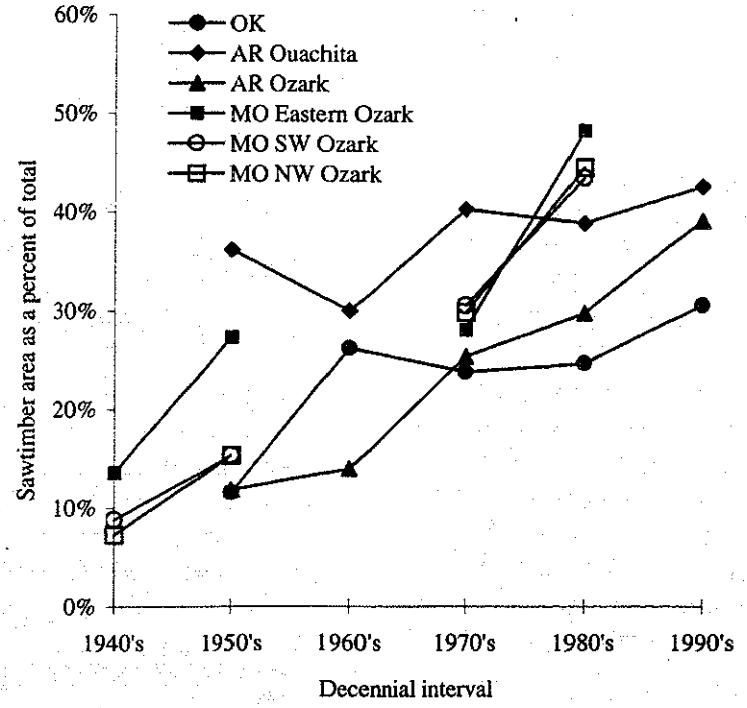


Figure 3.56—Percentage of commercial forest land area occupied by sawtimber stands by FIA region, 1940's to 1990's.

For the three intervals when all six regions were measured—the 1950's, 1970's, and 1980's—forest area in seedling/sapling- and poletimber-sized stands has decreased, and sawtimber area has increased (fig. 3.57). These data indicate an increasing maturity of the forests in the region over time. As stands recovered from the uncontrolled cutting at the turn of the century, tree size in stands increased. The ratio of area in these three size classes should stabilize at some point, but that does not appear to have happened yet.

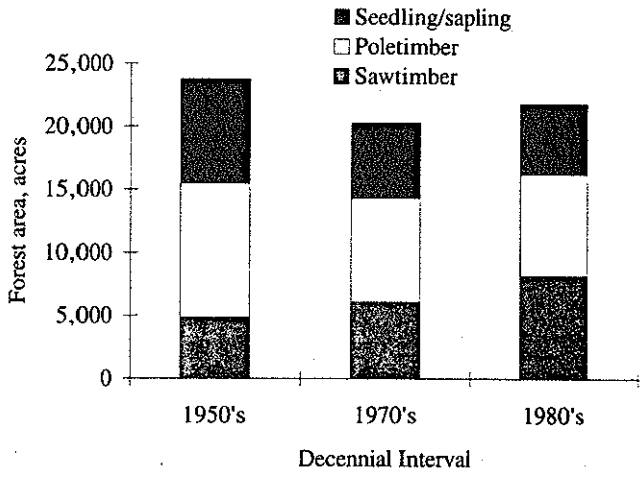


Figure 3.57—Distribution of commercial forest land area in the Assessment area by stand size class for the 1950's, 1970's, and 1980's.

Distribution by Forest Type

Loblolly-Shortleaf Pine Type. The loblolly-shortleaf pine type is somewhat of a misnomer in the Ozark-Ouachita Highlands. Shortleaf pine is the dominant naturally occurring pine in the region, with loblolly a distant second. Because over 90 percent of this type was in Arkansas and Oklahoma in the 1950's, the Missouri regions will not be included in the discussion.

Data show a prominent decrease in the pine type in the three survey regions in Arkansas and Oklahoma from the 1950's to the 1960's (fig. 3.58). This decrease was probably due in part to a real decline in acreage, and in part to changes in the way that FIA plots were measured and forest types assigned.

Nevertheless, the area in pine forest type in these three regions declined from 3.8 million ac in the 1950's to 2.2 million ac in the 1960's, a 1.6 million acre loss. Over 1 million ac were lost in the Ouachita region alone. By the 1990's, pine forest type had recovered to 1950's levels in Oklahoma and the Arkansas Ozarks, but was still only 60 percent of the 1950's level in the Ouachitas.

Another way to consider these data is that from the 1950's to the 1960's, these three regions lost nearly 1.78 million ac of timberland. Over the same time period, the pine type declined 1.61 million ac, or over 90 percent of the total forest area lost.

Several explanations are possible for this dramatic decline—all somewhat speculative. First, measurement standards for forest survey changed between the 1950's and 1960's (Hedlund and Earles 1970), and this may have affected the computation of area by forest type. The most logical direction for those changes would have been that some pine type areas were changed to oak-pine. However, the area of oak-pine type increased in only two of the three Arkansas and Oklahoma regions (fig. 3.59), and these increases fell

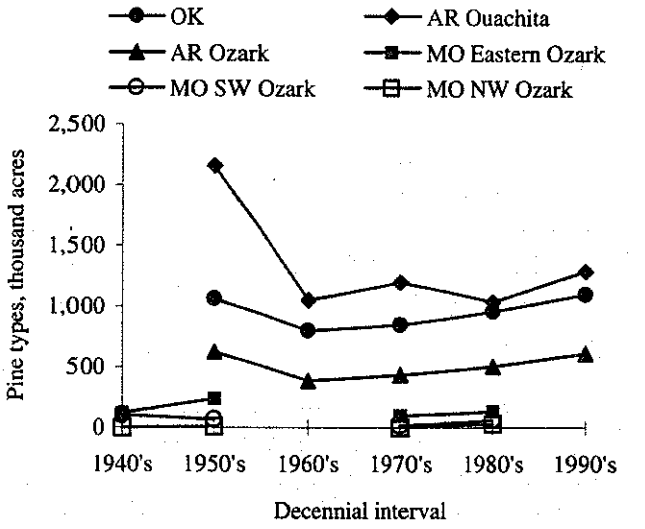


Figure 3.58—Commercial forest land area in the loblolly-shortleaf pine type by FIA region, 1940's to 1990's.

short of the magnitude of the decline in the pine forest type. A second possibility for the decline might be that an increase in agricultural land uses took land from forest areas entirely. A third possibility might be that continued selective harvesting of pines converted some areas to oak-hickory and other hardwood types rather than oak-pine types. In all probability, a combination of these factors was responsible for the decrease.

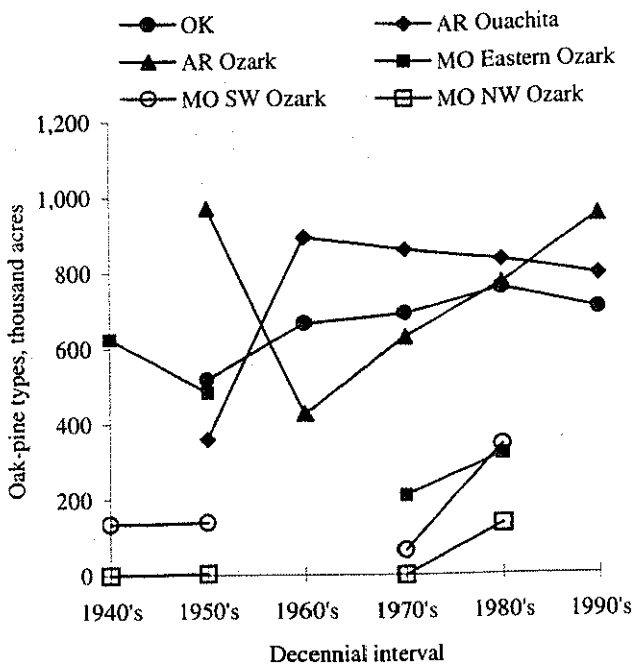


Figure 3.59—Commercial forest land area in the oak-pine type by FIA region, 1940's to 1990's.

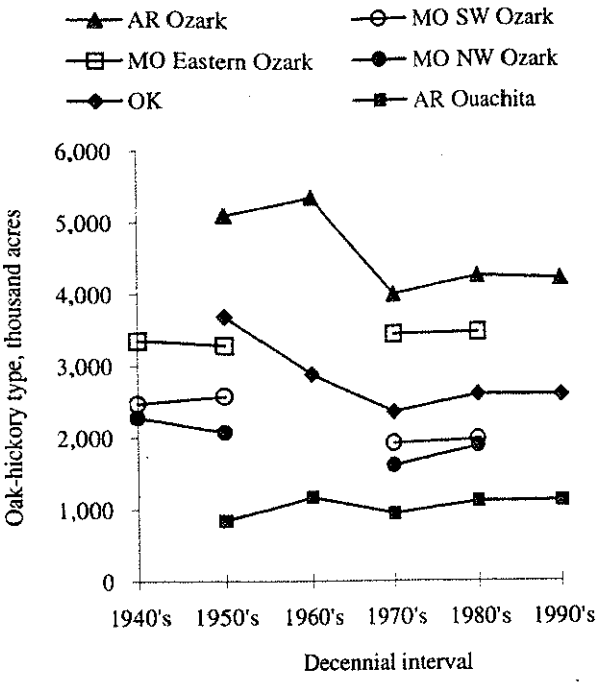


Figure 3.60—Commercial forest land area in the oak-hickory type by FIA region, 1940's to 1990's.

However, from the 1960's to the 1990's, pine-type areas increased 34 percent in the Oklahoma and Arkansas regions. Thus, the declines in pine-type areas seen between the 1950's and 1960's have been reversed, and pine area has generally increased over time since the 1960's.

Oak-Hickory Type. The oak-hickory type is the dominant forest type in the Arkansas and Missouri Ozarks and is also important in Oklahoma. Over time, the area in oak-hickory type has been relatively stable in Missouri and the Arkansas Ouachitas and less so in Arkansas and Oklahoma (fig. 3.60). A net decline of 1.7 million ac of this type occurred in the Arkansas and Oklahoma regions between the 1950's and 1990's. The largest drop was during the 1960's, probably due to the increased conversion of poor-quality oak-hickory stands to pasture land. This decline was partly offset by increases in pine percentage and partly by increases in other hardwood forest types.

In Missouri, percent forest area in the oak-hickory type has remained between 75 percent and 90 percent throughout the measurement period (fig. 3.61). In contrast, the Arkansas Ozark and Oklahoma regions have had steady declines in the proportion of total forest

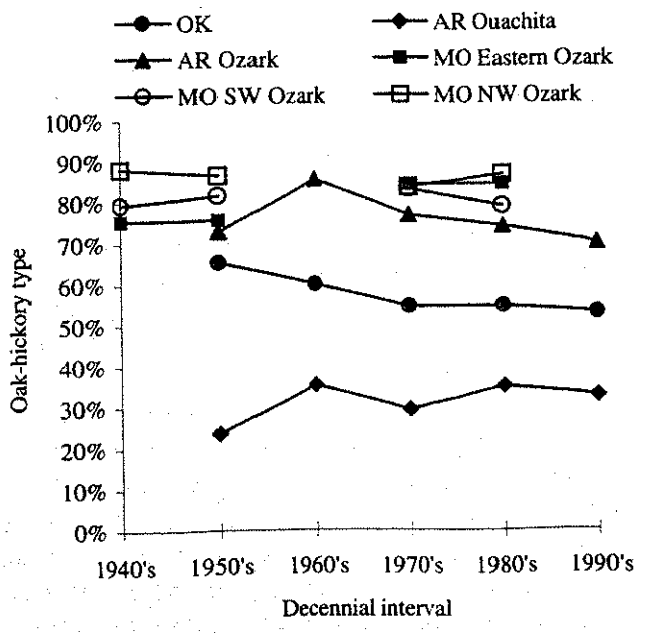


Figure 3.61—Percentage of commercial forest land area occupied by the oak-hickory type by FIA region, 1940's to 1990's.

area that oak-hickory type represents since the 1960's. Although the Ouachita region has the lowest percentage in the oak-hickory type—about 30 percent over the past three decennial intervals—its relative prominence on the landscape has increased since the 1950's.

Distribution by Growing-Stock Cubic Volume

Overall, the total growing-stock cubic volume increased in all regions over time (fig. 3.62). From the 1950's to the 1980's, growing-stock cubic volume nearly doubled, from 8.4 billion cubic feet to slightly more than 16 billion cubic feet. The distribution of this volume by State has been remarkably stable, as shown by the following tabulation:

State	Growing-stock volume	
	1950's	1980's
	Percent	
Arkansas	50.9	50.8
Missouri	33.5	35.3
Oklahoma	15.6	13.9

In addition, the rank by regions did not change from the 1950's to the 1980's—the Arkansas Ozarks had the greatest volume, the northwest Missouri Ozarks the lowest volume, and the other regions remained in the same rank order.

The growing-stock cubic volume of pine shows an increasing trend over time across all regions (fig. 3.63). Volumes generally increased from one decennial interval to the next. The exceptions were a decline in the Missouri Eastern Ozarks between the 1950's and 1960's, a decline between the 1970's and 1980's in the Ouachita region, and a slight decline in Oklahoma during that same interval. During the 1970's and 1980's, industry and national forests were actively cutting older pine stands and replacing them with fast-growing pine plantations. The increase in pine volume from the 1980's to the 1990's is consistent with this interpretation; plantations are now in their second and third decades of growth and, as a whole, contributed to the increased cubic volume over the past decennial interval.

The growing-stock volume of hard hardwood also shows a general increase over time (fig. 3.64). The area with the highest cubic volume of hard hardwoods is the

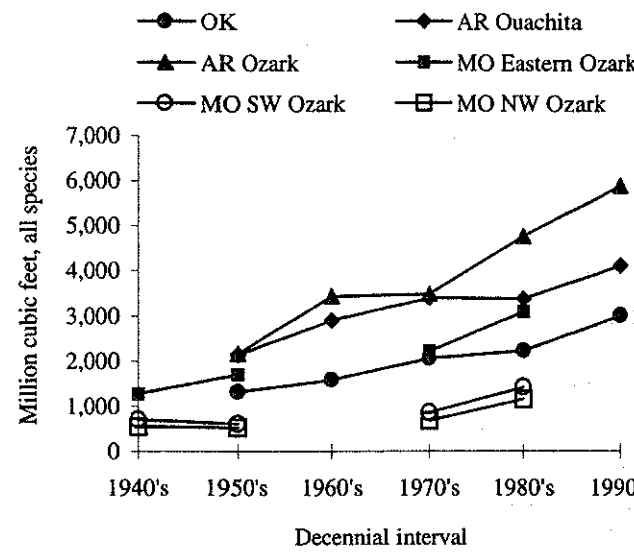


Figure 3.62—Growing-stock volume of all species on commercial forest land by FIA region, 1940's to 1990's.

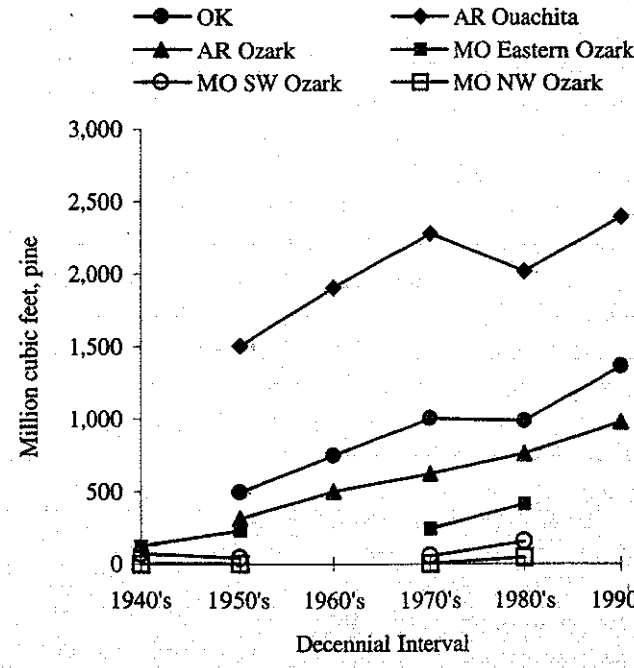


Figure 3.63—Growing-stock volume of the pine species group on commercial forest land by FIA region, 1940's to 1990's.

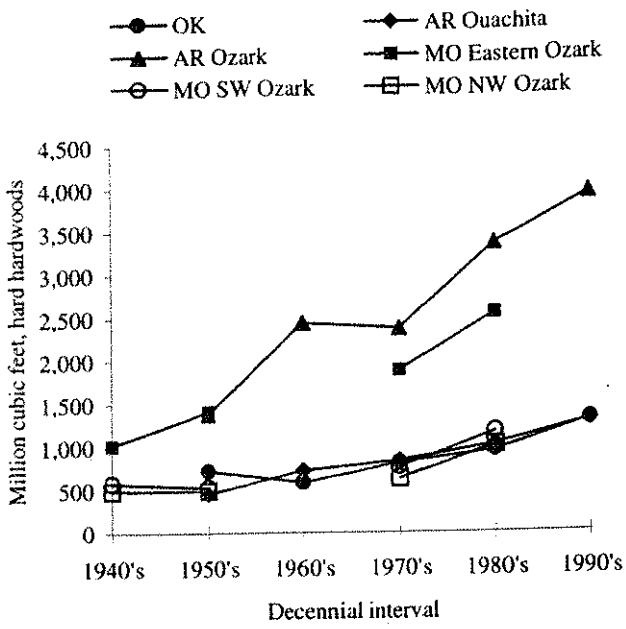


Figure 3.64—Growing-stock volume of the hard-hardwoods species group on commercial forest land by FIA region, 1940's to 1990's.

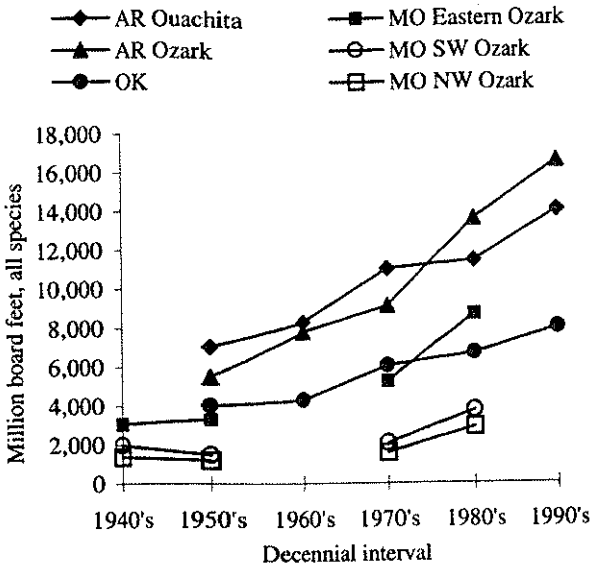


Figure 3.65—Sawtimber volume of all species on commercial forest land by FIA region, 1940's to 1990's.

Arkansas Ozarks, which increased from about 1.4 billion cubic feet in the 1950's to over 3.9 billion cubic feet in the 1990's. The slight decline in cubic volume from the 1960's to the 1970's suggests a withdrawal of marginal lands for agricultural use, which was common at the time. The eastern Missouri Ozarks show a similar increase in the hard-hardwood component over time, from roughly 1 billion cubic feet in the 1940's to slightly more than 2.5 billion cubic feet in the 1980's. Hard-hardwood volumes in the other regions roughly doubled across the four-decade span between the first and the latest decennial interval, and at the most recent interval all exceeded 1 billion cubic feet.

Distribution by Sawtimber Volume

Total sawtimber volume has increased over time (fig. 3.65). The biggest absolute increase from the 1950's to the 1980's was in the Arkansas Ozarks, which experienced an increase of 8 billion board feet. The largest percentage increase in sawtimber volume was in the eastern Missouri Ozarks, which had a 167 percent increase since the 1950's. In total, where the six regions were combined, they more than doubled in sawtimber volume over the past three decades, from 22 billion board feet to more than 45 billion board feet.

Pine-sawtimber volume has increased in all regions over time (fig. 3.66). The increases have been smallest in Missouri, larger in the Arkansas Ozarks and Oklahoma, and largest in the Arkansas Ouachita region. However, the percentage increase in pine-sawtimber volume has been greatest in the Missouri Ozarks, especially the eastern Missouri Ozark region, where pine volume has increased more than 400 percent relative to levels four decades previous. From the 1950's to the 1980's, pine-sawtimber volume across all six regions increased 77 percent.

Based on the 1980's decennial interval, the "other softwood (conifer)" component (primarily eastern red cedar) is about 2.5 percent of total softwood-sawtimber volume. However, volume in this species group has increased over time (fig. 3.67). From the 1950's to the 1980's, the other softwood-sawtimber volume increased more than any other species group, by more than 250 percent. Cedar is most prominent in the Arkansas Ozarks where, from the 1960's to the 1990's, cedar-sawtimber volume increased more than eightfold.

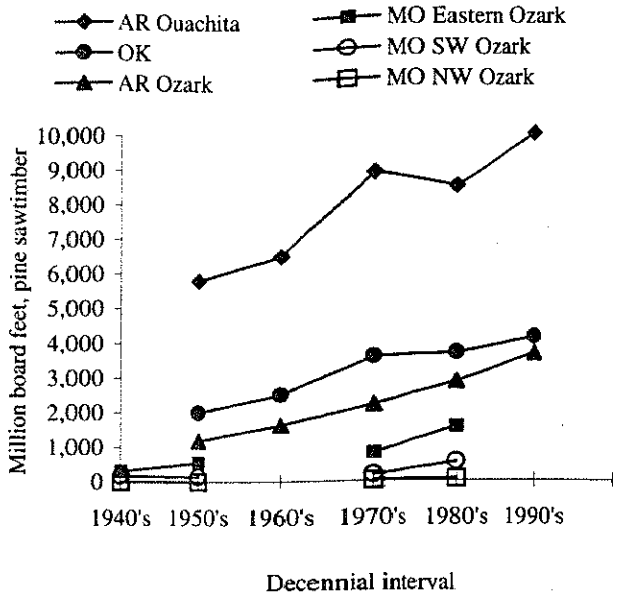


Figure 3.66—Sawtimber volume of the pine species group on commercial forest land by FIA region, 1940's to 1990's.

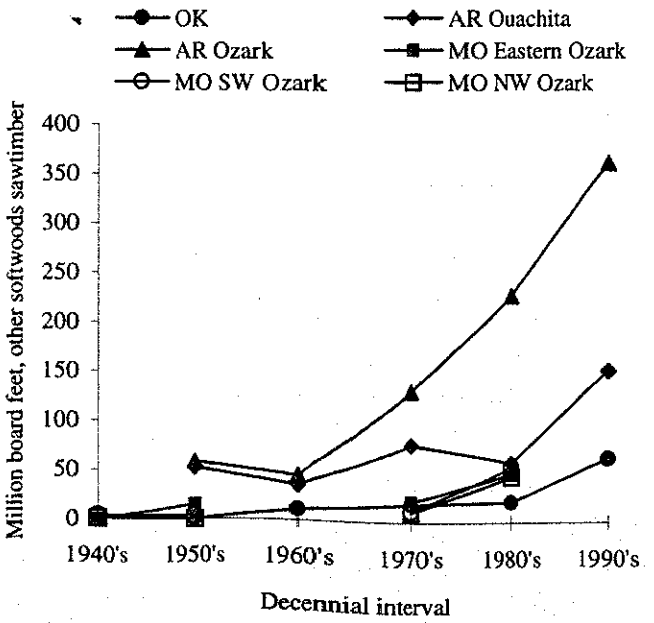


Figure 3.67—Sawtimber volume of the other softwoods species group on commercial forest land by FIA region, 1940's to 1990's.

Soft hardwoods had the smallest percentage increase in sawtimber volume of all four species groups (fig. 3.68). In the three Missouri regions, soft-hardwood sawtimber volume decreased sharply from the 1940's to the 1950's, but subsequently volumes have gradually increased.

The Oklahoma and Ouachita regions have seen slight increases in soft-hardwood sawtimber volume from one decade to the next, with volumes more than doubling over the four-decade interval. The largest increase in soft-hardwood-sawtimber volume has been in the Arkansas Ozarks, where volume almost doubled from the 1970's to the 1990's.

The hard-hardwood component has been the dominant sawtimber component in the Assessment area and continues to grow at a disproportional rate (fig. 3.69). Hard-hardwood volume increased from 10.6 billion board feet (47 percent of total sawtimber volume) in the 1950's to 26 billion board feet (55 percent of total sawtimber volume) in the 1980's.

Two of the six regions—the Arkansas Ozarks and the eastern Missouri Ozarks—had the greatest increases in hard-hardwood sawtimber volume. From the 1950's to the 1980's, these two regions supported an increase of greater than 10 billion board feet in hard-hardwood sawtimber volume—nearly 66 percent of the growth across the six regions.

Distribution of Volume in White Oak and Red Oak Groups

Together, the red oaks and white oaks are the major element of the hard hardwoods. But the dynamics of the two subgroups are slightly different over time. For example, across all regions, the percentage of oak volume in the red-oak group was relatively constant from the 1950's (48.5 percent of growing-stock cubic volume, 50.7 percent of sawtimber volume) to the 1980's (48.6 percent of growing-stock cubic volume, 55.5 percent of sawtimber volume).

The Ouachita, Oklahoma, and southwestern Missouri Ozarks regions, however, exhibit a trend in which the proportion of oak volume in the red oak group increases over time (fig. 3.70). The absolute volume of white oaks and red oaks is increasing. Differences between the two groups may be due to developmental dynamics or perhaps to different levels of harvest.

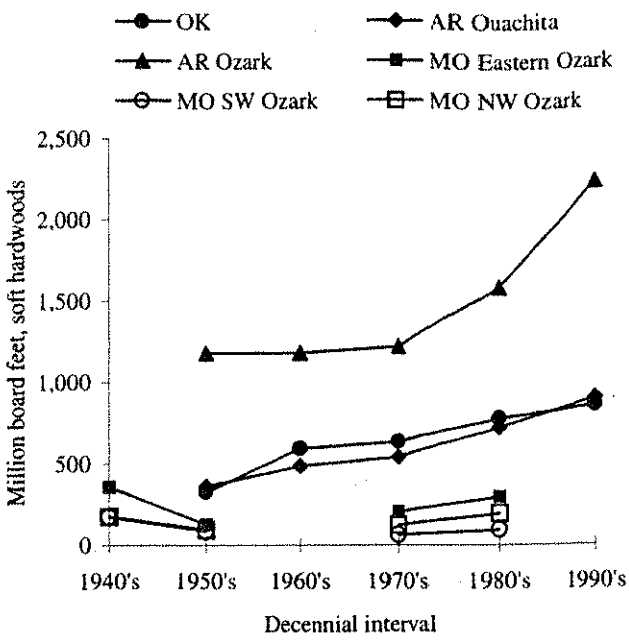


Figure 3.68—Sawtimber volume of the soft-hardwoods species group on commercial forest land by FIA region, 1940's to 1990's.

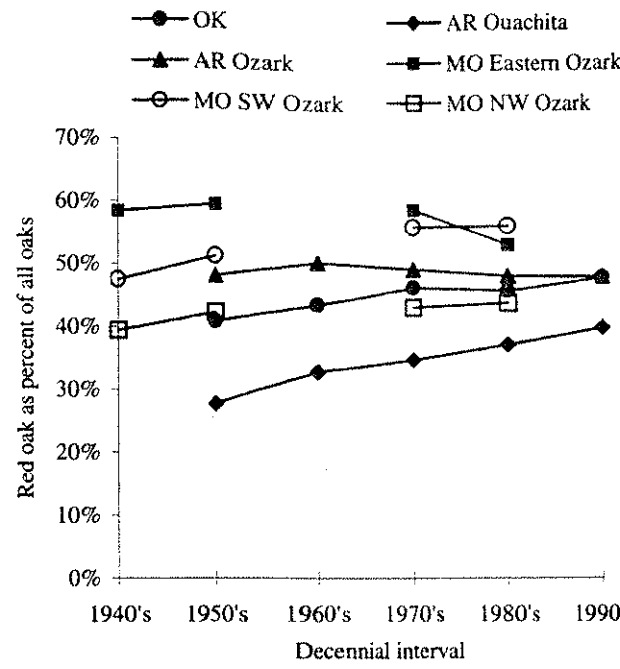


Figure 3.70—Red oak growing-stock volume as a percentage of all oak growing-stock volume on commercial forest land by FIA region, 1940's to 1990's.

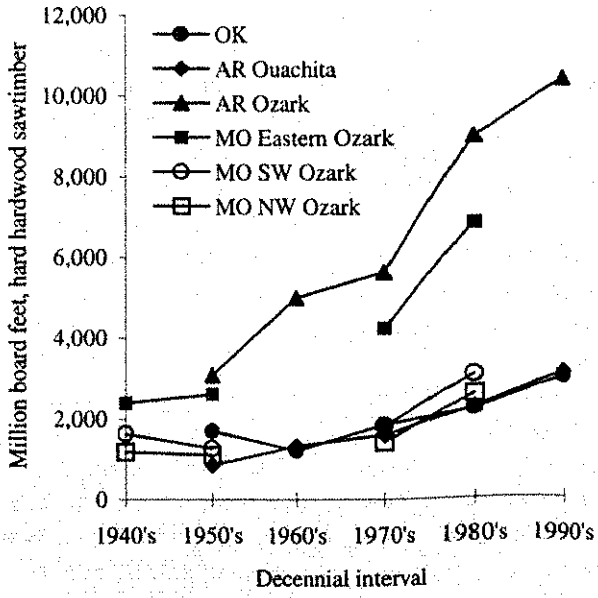


Figure 3.69—Sawtimber volume of the hard-hardwoods species group on commercial forest land by FIA region, 1940's to 1990's.

When the red oak and white oak groups are combined, they appear to account for a moderately increasing proportion of volume over time (figs. 3.71 and 3.72). For growing-stock cubic volume, the combined oaks constituted 48 percent of total volume in the 1950's and 52 percent in the 1980's. The increase is greater in sawtimber volume; oaks accounted for 39 percent of sawtimber volume in the 1950's and 47.6 percent in the 1980's.

Figures 3.71 and 3.72 show the proportion of oak cubic feet and sawtimber volume, respectively, by region. The Ouachita and Oklahoma regions have the lowest volume of the oaks (recall that the pine component dominates in these regions). Conversely, oaks provide over 70 percent of growing-stock and sawtimber volume in the three Missouri regions.

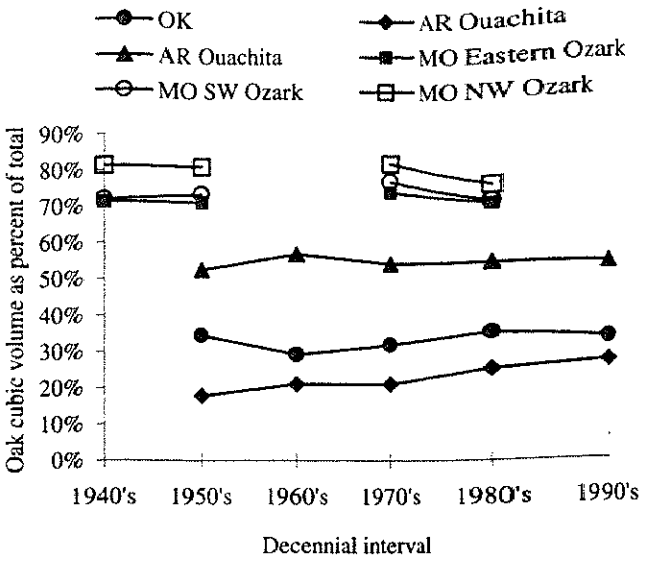


Figure 3.71—Oak growing-stock volume as a percentage of all species growing-stock volume on commercial forest land by FIA region, 1940's to 1990's.

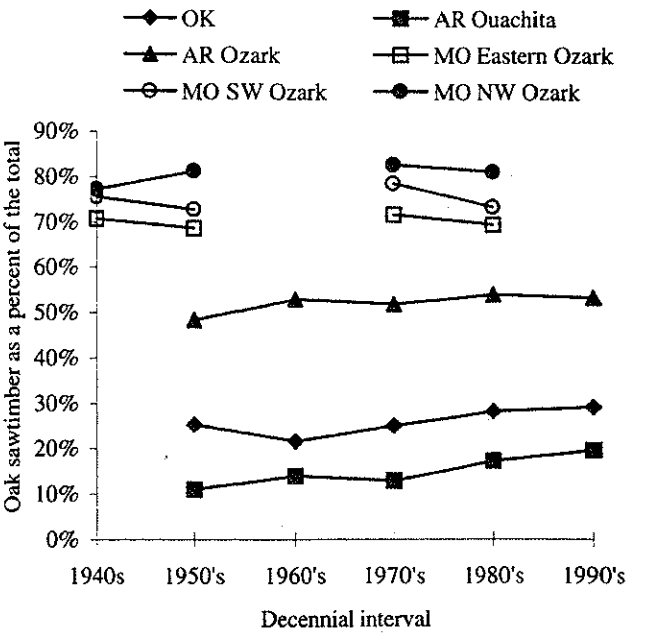


Figure 3.72—Oak sawtimber volume as a percentage of all species sawtimber volume on commercial forest land by FIA region, 1940's to 1990's.

Implications and Opportunities

National forests and other public lands will likely contribute significantly to the retention of forest cover in the region over the long term. Forests under public land management are unlikely to be converted to other uses. Furthermore, where timber harvests occur, the land is promptly reforested. Public lands, however, represent only 22 percent of the timberland acreage in the Highlands

Across the Highlands, the average annual net growth of trees is nearly 30 cubic feet/ac, while the average annual removals from harvesting are 14.5 cubic feet/ac. Mortality due to other causes claims 3.7 cubic feet/ac. Tree growth, therefore, exceeds "losses" by more than 11.8 cubic feet/ac per year. Removals and mortality, in other words, claim slightly less than 40 percent of annual tree growth. This is the first of many indicators that total tree biomass is increasing significantly in the Highlands.

The proportion of total forest cover represented by oak-hickory has declined steadily in the Arkansas Ozarks and slightly in Oklahoma over the past three decades. The simplest explanation is that, although total oak-hickory acres are stable or increasing, the acreage in pine and mixed pine-hardwood types is increasing even more rapidly. This trend is probably a result of oak-pine being replaced with pine.

The FIA trend data clearly show that the total volume of trees is increasing in the Highlands and has been for decades. Sawtimber volume and percent of forest in sawtimber are both substantially higher than in the 1970's in all six FIA regions. Sawtimber volume of hard hardwoods was four times greater in the 1990's than in the 1950's, and both oak cubic volume and oak sawtimber volume have remained steady as a percentage of total volume. Total cubic volume and cubic volume of both pines and hardwoods is substantially higher than in the 1950's. In the Arkansas Ozarks, the Ouachitas, and in easternmost Oklahoma, total cubic volume is two to three times greater than in the 1950's.

Old Growth

Scientists estimate that 90 percent of the virgin forests in the United States are gone. The remaining virgin stands are principally in the Northwest, on national park lands, or in isolated pockets on private or State lands (Noss and others 1995).

Very little virgin forest remains in the East, and most of it is in small, isolated stands. There are, however, stands having some characteristics of old-growth forest. Those characteristics typically include trees at least a century in age, the plants and animals associated with old trees, downed logs, and standing snags.

Disturbances, such as periodic fires, blow downs, and insect attacks, perpetuate these conditions in true old-growth forests. Old-growth conditions can gradually redevelop after timber harvests, natural catastrophic events, such as tornadoes, or even in agricultural fields.

At least 16 types of old-growth forests exist in the Southern United States. The Ozark-Ouachita Highlands could support seven of those types (Gaines and others 1997). The Terrestrial Team assessed existing and potential old-growth stands on the three national forests in the Ozark-Ouachita Highlands. Other Federal and State agencies could assess their lands for potential old growth, using the same criteria. In this report, the term "potential old-growth stand" refers to areas having some characteristics of old-growth stands, mainly trees of at least 100 years in age.

Data Sources

Any stand has the potential to become an old-growth forest. However, the presence of several characteristics of an old-growth forest can make a stand of public forest a better candidate for designation as potential old growth. The presence of old trees is a significant characteristic, yet many acres with suitably old trees lack other important characteristics, such as dead and downed trees or live trees with cavities for animal habitat.

The size of old-growth stands is another important consideration; plant and animal species utilizing old growth may respond differently to areas of various sizes. Gaines and others (1997) identified three size categories for management of old growth in the Southern Region: small patches of up to 99 ac, medium-sized patches of 100 to 2,499 ac, and large patches of 2,500 or more acres.

The process of identifying areas that merit designation begins with locating potential old-growth stands having some or all of the identified old-growth characteristics. After the stands have been located, an initial inventory of the oldest stands of different forest types must be conducted. Gaines and others (1997) have provided guidance to national forests in the South, and Tyrrel and others (1977) have provided guidance to national forests in the East for selecting stands for Federal designation as potential old-growth forests.

The Terrestrial Team used the Continuous Inventory of Stand Conditions, a geographic information system, to identify potential stands in the Ozark and Ouachita National Forests and the Combined Data System database to find potential stands in the Mark Twain National Forest. A spatial analysis of the Ozark and Ouachita National Forests' data enabled researchers to assemble adjacent potential old-growth stands of similar forest cover types on those forests.

Patterns and Trends

The Forest Service identified seven types of old-growth forests as potentially existing in the Ozark-Ouachita Highlands. Each is described below.

Dry and Xeric Oak Forest, Woodland, and Savanna

This widespread mix occurs on ridge tops and some southern slopes or rock outcrops of dry, infertile uplands where conditions are dry most of the year. Oaks, including post, black, white, and blackjack, dominate the overstory. The average ages of trees ranges from 65 to 150 years, depending on the species (Gaines and others 1997).

This community depends upon fire to control competition from smaller trees and other aggressive species of plants. Fires contribute to a more open canopy than in dry-mesic oak forests.

Xeric Pine and Pine-Oak Forest and Woodland

Shortleaf pines dominate stands of this type, which are found on dry, south-facing upper slopes where soils are acidic and poor in nutrients and little moisture is available. Black, blackjack, post, and white oaks are also part of the overstory and much of the mid- and lower-levels of the stand. Shortleaf pines average 200

years in age (Gaines and others 1997). The Lake Winona Research Natural Area in the Ouachita National Forest is an example of this type of old growth.

Frequent, low-intensity fires maintain this community's composition and structure. Windstorms, ice storms, and intense fires may cause large openings in these stands, and windblown trees may feed more intense fires. Pockets of younger trees then begin to renew the stand, as well as filling gaps caused by the deaths of individual trees from lightning, insect attack, or old age. The Ouachita National Forest is managing 38 sites for future xeric pine and pine-oak old-growth forests, using fire and other management techniques.

Dry-Mesic Oak Forest

This type occurs primarily on north-facing slopes and at the bottoms of south-facing slopes. The species in this type of old growth, which vary depending upon location and elevation, include oaks, hickories, and maples tolerant of dry conditions. Shortleaf pine may occur but does not make up more than 25 percent of the stand. Trees are more than 300 years old (Gaines and others 1997).

Fire is an important factor in maintaining these forest communities. Thick-barked oaks easily survive frequent, low-intensity fires, while more sensitive, thin-barked species, such as maples, succumb readily to fires. Thus, fires produce widely-spaced larger trees with understories of herbaceous plants, allowing germination of new growth in sunlit or mostly sunlit areas.

Dry and Dry-Mesic Oak-Pine Forest

This type develops on the same kind of sites as the dry-mesic oak forest. White oak dominates the stands with shortleaf pine occupying at least 20 percent. Oaks and pines can reach 300 years in age (Gaines and others 1997).

Frequent fire maintains the structure of this type of old-growth forest by recycling nutrients (releasing nutrients in dead and decaying material) and controlling competition. More intense fires renew stands by removing large patches of trees or individual trees.

Mixed Mesophytic and Western Mesophytic Forest

One of the most biologically diverse ecosystems in the United States, this type may occur in coves or on north- or east-facing slopes throughout the Ozark-Ouachita Highlands. Oaks dominate the communities in this broad category, but the forests may also include sugar maple, beech, basswood, and red maple. They are uneven- or all-aged stands, with the maximum age for basswood, the indicator or key species for this community, being 198 years (Gaines and others 1997).

Deaths of individual trees create small gaps in the canopy, permitting new growth in these stands. Less frequent disturbances from fire, windstorms, floods, and other natural events also create openings for renewal of the forest.

Seasonally Wet Oak-Hardwood Woodland

Hardwood species that thrive in wet conditions, such as willow oak, sweetgum, and red maple, make up this type. The semi-open woodlands require standing or subsurface water; upland trees cannot survive in this community. Large trees in this community are between 80 and 100 years old (Gaines and others 1997).

Infrequent fires in conjunction with dry years can eliminate woody debris and cause isolated tree deaths. These fires break down dead timber and leaf litter, improving the nutrient return to the soil and supporting new growth. Suppression of these renewing fires has caused stands of this type to develop into dense forests instead of open woodlands. Under this condition, growth of individual trees is poor, leaving the entire stand vulnerable to disease and insect threats.

River Floodplain Hardwood Forest

This type occurs along large rivers such as the Arkansas, the Current, the Eleven Point, and the White, often on the most productive soils in the area. A mix of oaks, red maple, hickory, birch, ash, sweetgum, and elms make up the tallest trees in the canopy. The dominant trees reach a maximum age of more than 100 years. American beech may be present at the first bench above the floodplain (Gaines and others 1997).

Catastrophic floods infrequently destroyed entire stands of this type in the past. With the damming of the Arkansas, Ouachita, and White Rivers to control floods,

it is more typical for individual trees to succumb to changes in water level. Changes to a river's course occasionally isolate portions of these stands, causing them to lose their old-growth characteristics. Fires occur infrequently in these communities due to the year-round presence of moisture.

Designated Old Growth

Within the Assessment area, almost all designated old-growth stands (ones the national forests manage for old-growth characteristics) are xeric pine and pine-oak or dry and dry-mesic oak-pine forests (table 3.10). The only designated old-growth areas in the Highlands exceeding 2,500 ac are parts of federally designated wilderness. The national forests within the Ozark-Ouachita Highlands have the following numbers of wilderness areas and total acres of wilderness per forest:

National forest	Areas	Area
		Acres
Mark Twain	6	63,627
Ouachita	7	65,974
Ozark-St. Francis	5	66,931

In addition, the McCurtain County (OK) Wilderness Area, which the Oklahoma Department of Wildlife Conservation manages, includes approximately 13,000 ac of old-growth xeric pine and pine-oak (Kreiter 1995). The Buffalo National River in northern Arkansas contains three wilderness areas with 10,529 ac of dry-mesic oak, dry and xeric oak, and river floodplain hardwood.

The designation of land as wilderness can affect the potential for development of old growth because it restricts managers from using some techniques that would support restoration of old-growth characteristics. Thus, wilderness may not be the best choice for perpetuating some types of old growth.

Potential Old Growth

Each potential old-growth type is represented by existing forest cover on one or more of the Highland's national forests. Table 3.11 shows the percent cover of these types on the three national forests (excluding wilderness). On the Mark Twain National Forest, dry and xeric oak, xeric pine and pine-oak, and dry and dry-mesic oak-pine make up 98 percent of the existing forest types. On the Ozark National Forest, 66 percent of the existing forest cover is dry-mesic oak, and 29 percent is xeric pine and pine-oak. These figures are nearly reversed on the Ouachita National Forest, where xeric pine and pine-oak forests cover 69 percent of the area and dry-mesic oak covers 21 percent.

Table 3.12 summarizes the estimated number of potential old-growth stands in the national forests by forest type and stand size class. No large stands (> 2,500 ac) of potential old-growth (of a given forest type) were identified on these national forests. However, it seems likely that if adjacent, medium-size stands (100–2,500 ac) of different forest types were considered, examples of the "large" size class could be identified. Xeric pine and pine-oak potential old-growth stands were the most numerous on the Ozark and Ouachita National Forests; dry and xeric oak stands were the most numerous potential old-growth stands on the Mark Twain National Forest.

Table 3.10—Acreage and types of designated old-growth areas in the national forests of the Ozark-Ouachita Highlands

National forest	Area	Old-growth type
	Acres	
Ouachita	80,468	XP-PO, DDM-OP
Ozark	9,656	XP-PO, DDM-OP
Mark Twain	122,519	XP-PO, DDM-OP, DMO, DXO, RFH
Total	212,643	

XP-PO = xeric pine and pine oak; DDM-OP = dry and dry-mesic oak-pine; DMO = dry-mesic oak; DXO = dry and xeric oak; RFH = river floodplain hardwood.

Implications and Opportunities

Because they are more resilient, the more common types of old-growth forests may need relatively little intervention for conservation or restoration. Less common types may need more management, even

Table 3.11—Percent of existing forest cover in seven potential old-growth cover types, by national forest (excluding wilderness)

Cover type	Mark Twain NF	Ozark NF	Ouachita NF
Mixed and western mesophytic	0	0.25	0.13
River flood plain hardwood	1.23	0.51	0.30
Dry-mesic oak	0	65.86	20.60
Dry and xeric oak	70.12	0.01	0.69
Xeric pine and pine-oak	9.08	29.38	69.34
Dry and dry-mesic oak-pine	19.44	2.76	8.43
Seasonally wet oak-hardwood	0.13	1.32	0.52
Total[a]	100.00	100.00	100.00

[a] Percent totals rounded to 100.

Table 3.12—Number of potential old-growth stands in the three national forests of the Ozark-Ouachita Highlands by forest type and stand size

Old-growth forest type	Stand size class[a] Small	Medium	Large	Total
		Ozark National Forest		
Mixed and western mesophytic	0	0	0	0
River floodplain hardwood	623	859	0	1,482
Dry-mesic oak	1,385	437	0	1,822
Dry and xeric oak	0	0	0	0
Xeric pine and pine-oak	4,412	1,732	0	6,144
Dry and dry-mesic oak-pine	111	0	0	111
Seasonally wet oak-hardwood	97	0	0	97
Total	6,628	3,028	0	9,656
		Ouachita National Forest		
Mixed and western mesophytic	0	0	0	0
River floodplain hardwood	245	0	0	245
Dry-mesic oak	556	977	0	1,533
Dry and xeric oak	271	0	0	271
Xeric pine and pine-oak	16,960	15,572	0	32,532
Dry and dry-mesic oak-pine	360	415	0	775
Seasonally wet oak-hardwood	163	0	0	163
Total	18,555	16,964	0	35,519
		Mark Twain National Forest		
Mixed and western mesophytic	—	—	—	0
River floodplain hardwood	—	—	—	910
Dry-mesic oak	—	—	—	31,886
Dry and xeric oak	—	—	—	55,393
Xeric pine and pine-oak	—	—	—	723
Dry and dry-mesic oak-pine	—	—	—	4,953
Seasonally wet oak-hardwood	—	—	—	0
Total				93,865

— = not available.

[a] Small = 1 to 99 ac; medium = 100 to 2,499 ac; large = 2,500+ ac.

restoration, to perpetuate them as part of the Ozark-Ouachita Highlands. The emphasis should be to put together a desired condition and a clear set of guidelines for managers to follow for each type of old growth.

With most designated old-growth forest stands in the categories of xeric pine and pine-oak or dry and dry-mesic oak-pine, clear priorities for future old-growth stands are needed. Policymakers will need to determine whether each national forest should promote old-growth stands of each type or whether they concentrate on expanding the number and/or size of old-growth stands of the types most typical to the individual national forest. These old-growth forest types might represent the greatest opportunity for restoration.

Rare Communities

The concept of "rare community" is relatively new in ecology. For decades, scientists have identified certain species of plants and animals as rare. More recently, ecologists have recognized entire communities in nature may become rare or may have always been rare because they exist on restricted sites or because of a variety of imposed factors. Timber harvests; conversion of land for grazing, development, or other uses; flooding for lake systems; fire suppression; and other factors may cause declines in the health of various ecological communities so that some become rare. Types of rare communities include old-growth forest communities (see the preceding section) as well as prairies, glades, and shrublands.

Data Sources

There has been no thorough interagency inventory of rare communities, and therefore data concerning rare communities within the Assessment area are extremely limited. The list of rare communities in table 3.13 is based on a national classification system developed by The Nature Conservancy (Weakley and others 1996, 1997). The table is a preliminary summary and may exclude some types of rare communities that are actually present in the Highlands.

Patterns and Trends

Table 3.13 presents 21 types of rare communities that occur in the Assessment area. Types are in three categories: forests and woodland, shrubland, and grassland. Ten community types appear in the forest and woodland category, four in the shrubland category, and seven in the grassland category.

Implications and Opportunities

Conservation agencies in Missouri, Oklahoma, and Arkansas have met with representatives of the three national forests in the Assessment area to discuss management of rare communities, tracking actions, and naming systems. Revision of management plans for the national forests in the Assessment area will present additional opportunities for State and Federal agencies to collaborate in planning for the management or restoration of rare communities.

The three national forests and other cooperating agencies plan to use the National Classification System being developed by The Nature Conservancy. That system should be specific yet flexible enough to meet the needs of individual agencies while facilitating information sharing. When complete, this classification system may be a useful addition to Forest Service data bases.

Table 3.13—Types of rare communities in the Ozark-Ouachita Highlands, with TNC and State nomenclature, global ranking, States of occurrence, and reason for rarity

Nomenclature	Global rank[a]	States of occurrence	Reason for rarity
		Forest and Woodland Types	
I.A.8.N.b.030. *Pinus echinata/Vaccinium* Dry shortleaf pine-oak forest	G2	AR, OK, MO	Few old growth examples
I.B.2.N.a.070. *Acer saccharum-Quercus rubra-Carya cordiformis* Mixed mesophytic forest	G2Q	AR, OK, MO	Limited distribution
I.B.2.N.b.070. *Q. alba/Vaccinium* spp. Stunted white oak woodland	G1G2	AR, OK	Limited distribution
I.B.2.N.a.280. *Q. alba-C. ovata/Ostrya virginiana* *Q. alba-C. ovata* forest association	G2G3	OK, MO	Few old growth examples
I.B.2.N.b.090. *Q. stellata montaine* Stunted post oak-blackjack oak woodland	G1	MO	Limited distribution
I.B.2.N.e.120. *Q. palustris-Q. bicolor/Carex critina/Sphagnum* spp. Pin oak-swamp oak seasonally flooded forest	G1Q	MO	Conversion to nonforest
I.C.3.N.a.050. *P. echinata-Q. velutina/Vaccinium* spp. Dry shortleaf-pine-oak-hickory forest	G2G3	AR, MO	Fire exclusion, few old growth examples
II.A.4.N.a.070. *P. echinata-Schizachyrium scoparium* Shortleaf pine-little bluestem woodland	G2	AR, OK, MO	Harvesting, fire exclusion
II.B.2.N.a.170. *Q.stellata-Q. velutina-Q. alba-(Q. falcata)/Croton michauxii* Post oak-black oak-white oak-croton woodland	G2Q	AR, MO	Disturbance, conversion
II.C.3.N.a.050. *P. echinata-Q. alba* Xeric shortleaf pine-white oak	G2		Fire exclusion
		Shrubland	
III.A.2.N.g.010. *Aruninaria gigantea ssp. gigantea* Giant cane shrubland	G2	AR, OK	Disturbance, conversion
III.B.2.N.a.080. *Toxicodendron radicans/Polymnia canadensis* Poison ivy-leaf cup	G2	AR, OK	Infrequent on sandstone talus

(continued)

Table 3.13—Types of rare communities in the Ozark-Ouachita Highlands, with TNC and State nomenclature, global ranking, States of occurrence, and reason for rarity (continued)

Nomenclature	Global rank[a]	States of occurrence	Reason for rarity
		Shrubland (continued)	
Toxicodendron radicans/Polymnia cossatotensis Poison ivy-leaf cup	G1	AR	Infrequent on novaculite talus
III.C.2.N.c.010. *Juniperus virginiana var. virginiana-Andrachne phyllanthoides* Eastern redcedar-andrachne	G2	AR, OK	Limited to certain streamside zones
		Grassland	
V.A.5.N.a.010. *Andropogon gerardii-Panicum virgatum* Tallgrass prairie	G2G3	OK	Conversion, fire exclusion
Andropogon gerardii-Calamagrostis canadensis-Helianthus grosseserratus Bluestem tallgrass prairie	G2G3	AR, OK, MO	Conversion, fire exclusion
V.A.5.N.a.100. *Schizachyrium scoparium-Sorghastrum nutans-Aristida lanosa-Polypremum procumbens* Southern sand prairie	G1Q	AR, MO	Conversion, fire exclusion
Schizachyrium scoparium-Silene regia Lowland sand prairie	G2?	OK, MO	Conversion, fire exclusion
Schizachyrium scoparium-Sorghastrum nutans-Danthonia spicata-Silene regia Glade	G2	OK, MO	Limited distribution
V.A.5.N.c.110. *Schizachyrium scoparium-Sporobolus neglectus* Chert glade	G1?	OK, MO	Limited distribution
V.A.5.N.c.120. *Schizachyrium scoparium-Bouteloua curtipendula-Atrostis hyemalis-Eleocharis spp.* Little bluestem hardpan prairie	G2?	OK, MO	Limited distribution

TNC = The Nature Conservancy.
[a] Ranking based on known distribution, with global rank "1" (G1) representing the rarest element of interest and G5 the most common; see Chapter 5 for a complete description of global and state ranks.