United States
Department of
Agriculture

Forest Service

Southern
Research Station

General Technical
Report SRS-31

Ozark-Ouachita Highlands Assessment

Summary Report

REPORT

1

OF 5

Cover photo: Sunrise in the Ouachita Mountains.

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."

December 1999

Southern Research Station
P.O. Box 2680
Asheville, North Carolina 28802

Ozark-Ouachita Highlands Assessment:

Summary Report

Eastern Region
U.S. Department of Agriculture
Forest Service
Milwaukee, WI

North Central Research Station
U.S. Department of Agriculture
Forest Service
St. Paul, MN

Southern Region
U.S. Department of Agriculture
Forest Service
Atlanta, GA

Southern Research Station
U.S. Department of Agriculture
Forest Service
Asheville, NC

Contents

Preface

The *Summary Report* is one of five reports that document the results of the Ozark-Ouachita Highlands Assessment. Federal and State natural resource agencies and university cooperators worked together to produce the four technical reports that examine air quality, aquatic conditions, social and economic conditions, and terrestrial vegetation and wildlife. Dozens of experts in various fields provided technical reviews. Other citizens were involved in working meetings and supplied valuable ideas and information.

The *Summary Report* provides an overview of the key findings presented in the four technical reports. The latter offer much more detailed data, findings, and discussion of implications as well as links to many additional sources of information. References to other publications and data bases are kept to a minimum in the *Summary Report*, whereas the more detailed reports include hundreds of such references.

The USDA Forest Service initiated the Assessment and worked with other agencies to develop a synthesis of the best information available on conditions and trends in the Ozark-Ouachita Highlands. Assessment reports emphasize those conditions and trends most likely to have some bearing on the future management of the region's three national forests—the Mark Twain, Ouachita, and Ozark-St. Francis. People who are interested in the future of the region's other public lands and waters, or of this remarkable region as a whole, should also find the reports valuable.

No specific statutory requirement led to or guided the Assessment. However, data and findings assembled in the reports should provide a helpful context for any evaluation of possible changes needed in the land and resource management plans of the Highlands' three national forests. The National Forest Management Act directs the Forest Service to revise such management plans every 10 to 15 years, which means that the national forests of Arkansas, Missouri, and Oklahoma are due to have revised plans in the year 2001. Due to restrictions in the annual appropriations bills for the Forest Service, it is uncertain when these revisions can begin, let alone be completed; revision efforts could be underway, however, as early as the latter part of 2000.

The charter for the Ozark-Ouachita Highlands Assessment established a team structure and listed tentative questions that the teams would address. Assembled in mid-1996, the Terrestrial, Aquatic and Atmospheric, and Human Dimensions (Social-Economic) Teams soon refined and condensed these questions and then gathered and evaluated vast quantities of information. They drafted their key findings in late 1997 and refined them through mid-1999. In addition to offering relevant data and key findings in the reports, the authors discuss some of the possible implications of their findings for future public land management in the Highlands and for related research. The Assessment reports, however, stop well short of making decisions concerning management of any lands in the Highlands or about future research. In no way do the reports represent management "plans". Instead, the findings and conclusions offered in the Assessment reports are intended to stimulate discussion and further study.

Contributors to This Report and Acknowledgments

Assessment Team Leaders

William F. Pell, Assessment Team Leader and compiler of this report, USDA Forest Service, Ouachita National Forest, Hot Springs, AR.
George A. Bukenhofer, Terrestrial Team Leader, USDA Forest Service, Ouachita National Forest, Heavener, OK
J. Alan Clingenpeel, Aquatic and Atmospheric Team Leader, USDA Forest Service, Ouachita National Forest, Hot Springs, AR.
Daniel J. Nolan, Jr., Social and Economic Team Leader, USDA Forest Service, Ouachita National Forest, Hot Springs, AR.

Ozark-Ouachita Highlands Assessment Steering Team

G. Samuel Foster, Assistant Station Director of Research Programs–West, USDA Forest Service, Southern Research Station, Asheville, NC.
Randy Moore, Forest Supervisor, USDA Forest Service, Mark Twain National Forest, Rolla, MO.
Lynn C. Neff, Forest Supervisor, USDA Forest Service, Ozark-St. Francis National Forests, Russellville, AR.
Alan G. Newman, Forest Supervisor, USDA Forest Service, Ouachita National Forest, Hot Springs, AR.

Editorial Team

Donna M. Paananen, Technical Publications Writer-Editor, USDA Forest Service, North Central Research Station, East Lansing, MI.
Louise A. Wilde, Production Editor, USDA Forest Service, Southern Research Station, Asheville, NC.

Acknowledgments

The Steering Team for the Ozark-Ouachita Highlands Assessment would like to express its sincere appreciation for the long hours of dedicated work contributed by the four Assessment Team Leaders (named above), the production staff, and the many individuals from a variety of Federal and State agencies and institutions who contributed in any way to the final publication of this and the four other Assessment reports. (Contributors', reviewers', and production staff names are listed in the companion reports.)

In addition, the Steering Team would like to thank members of the public who attended meetings and/or provided written or oral input during the Assessment process. All played a role in the development of the final five Assessment reports.

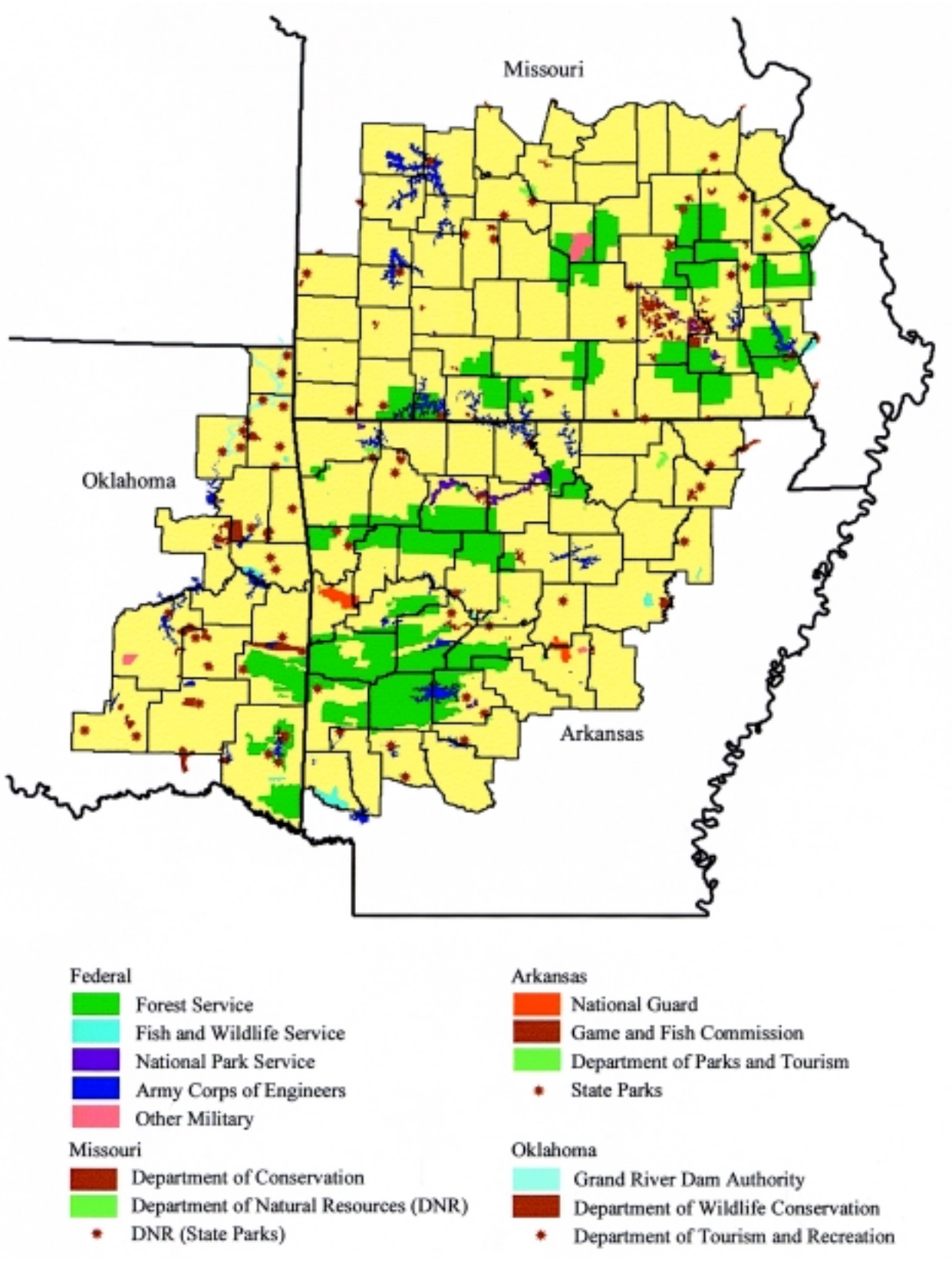


Figure 1—The Ozark-Ouachita Highlands Assessment area includes 107 counties and 6.5 million acres of public lands managed by the Federal and State agencies listed in the legend.

The Highlands

The Ozark-Ouachita Highlands Assessment focuses on a geographic area that includes portions of Arkansas, Missouri, and Oklahoma (fig. 1). The Assessment area is home to nearly 4 million people and includes about 6.5 million acres (ac) of public lands and waters.

Change is evident across the Highlands. Whether following State or regional news, studying statistical patterns and trends, or driving through the area, one cannot avoid the signs that many of its communities and at least some of its natural environments are undergoing rapid change. Urban and suburban development, planned communities, transportation networks, water distribution systems, and a variety of economic sectors are expanding, all driven by a growing and increasingly prosperous population. Naturally, how people regard the changes that are occurring varies widely, as does access to reliable information that might help individuals assess the significance of what is happening. The Assessment reports provide windows to a wealth of such information.

Growth and change do not occur without conflicts. Proposals for new or expanded reservoirs, landfills, and new or improved highways or airports are often controversial. Commercial and residential developments in some parts of the Highlands are placing new strains on community infrastructure. In some areas, there are disagreements over the proper balance between private property rights and "the public good." Concerns about the environmental effects of agricultural wastes and some kinds of resource extraction are also growing.

Many people nonetheless rate overall conditions and trends in the Ozark-Ouachita Highlands very favorably. The region's reputation for unspoiled beauty is still intact and largely deserved. A low-altitude flight over the Ozarks or Ouachitas still reveals vast expanses of natural-appearing forests (fig. 2), appealing pastoral landscapes, hundreds of miles of sparkling streams and lakes, and dozens of attractive, small communities. The populations of many species of wildlife are stable or increasing. Among the area's many amenities are several of the Nation's cleanest lakes, more than 6 million ac of public land, and more than 500 miles (mi) of federally protected rivers. Human population density remains relatively low in the Highlands. And although high poverty rates persist in many counties, economic growth has been steady, and poverty is declining in some areas.

Are the Highlands, then, basically in good shape—capable of accommodating more growth and sustaining a higher quality of life for more people—or does the region face serious challenges or even crises? Can the Highlands, and particularly its public lands, be described as "healthy?" What roles do public lands play in the social and economic life and the environmental quality of the area? Some answers, or at least a basis for informed discussions, have emerged from the key findings discussed in this report. Similarly, needs for additional information and research became apparent during the data collection and analysis of information.

The Assessment reports offer a wealth of information about the Highlands as a whole and about the many roles and relationships of public lands within that region. The status of the Highlands as a whole and of its public lands and waters are intimately connected; their futures are intertwined (fig. 3). Assessment teams sought to explore and better understand these connections.

For example, net migration of people moving to the Highlands was strongly positive in the 1990's. Studies suggest that migration within the United States during that decade was correlated with the "natural amenities"

Figure 2—Extensive, natural-appearing forests cover large portions of the Ozark-Ouachita Highlands; prairies, pastures, and human communities cover smaller areas.

Figure 3—Large reservoirs, many built and maintained by the U.S. Army Corps of Engineers, cover about 673,000 acres in the Highlands and provide strong draws for retirees and recreation visitors.

offered by certain nonurban parts of the country, including many counties in the Highlands. An analysis of results from a recent nationwide study by the USDA Economic Research Service reveals that the "Natural Amenities Index" for 43 percent of the counties in the Assessment area fell within the top 25 percent of counties in the United States, and fully 87 percent of the Highlands counties were in the top half (fig. 4).

Although public lands have not been factored specifically into the Natural Amenities Index used in these studies (the index is based on such factors as surface water area, topography, and climate), these lands clearly play important roles in sustaining the values associated with clean lakes and streams, forest cover, and bountiful recreation opportunities. How agencies manage the public lands and waters of the Highlands, then, surely contributes in important ways to regional economic and social conditions (as well as environmental ones), even though actual revenues or the number of jobs directly attributable to public land management may seem low.

Another example of the importance of the interconnections between public lands and surrounding lands and communities are the ways the recreation offerings of Federal and State lands complement or "compete" with those of private or corporate lands. What one sector provides in the way of campgrounds, hunting opportunities, or trails potentially affects all other sectors. Given that the demand for nearly all categories of recreation activity is expected to increase in the next decade, it would probably behoove recreation providers to know as much as possible about recreation supply and demand in the Highlands before proposing to expand or limit a particular recreation opportunity.

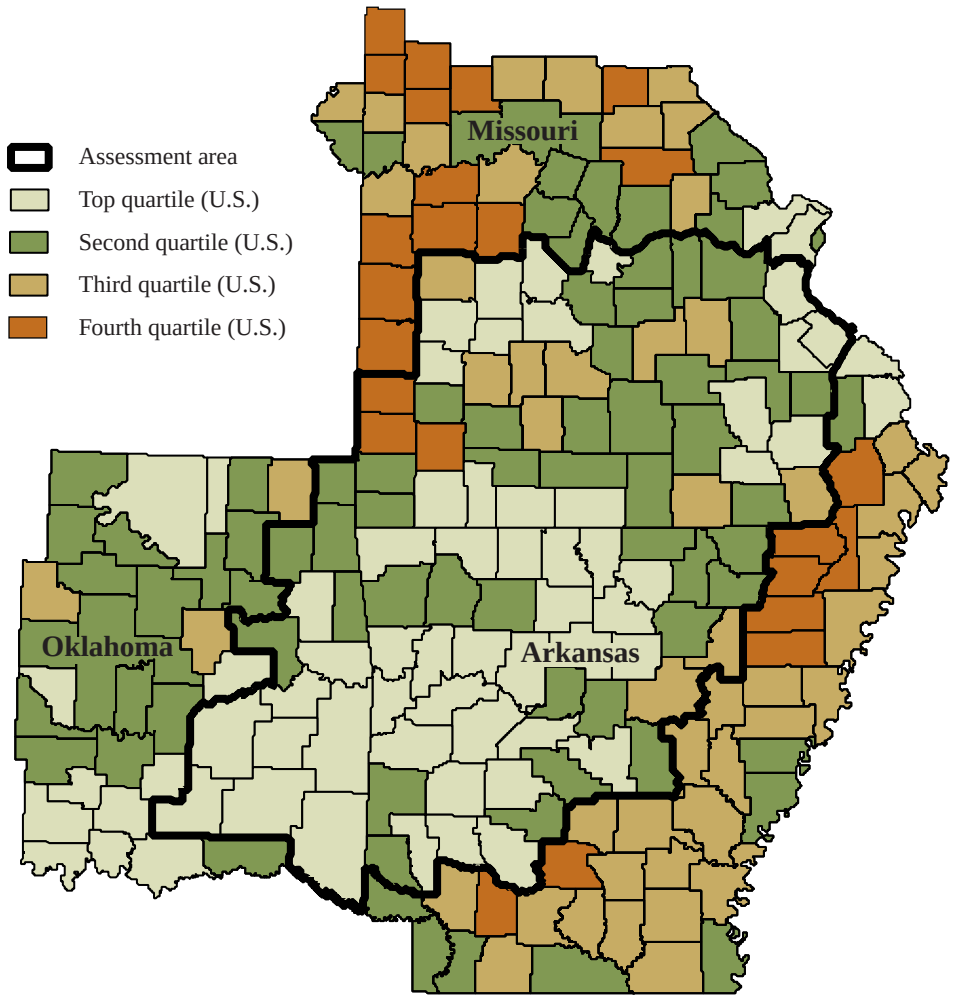


Figure 4—The "Natural Amenities Index" for 43 percent of the counties in the Assessment area was within the top 25 percent of counties in the United States.

Similarly, most lumber mills in the Highlands process logs from private or corporate lands and from one or more of the national forests; to consider national forest timber sales in isolation from the regional supply and demand for timber would be shortsighted at best.

Public lands in the Highlands include over 164,000 ac of lands managed by the National Park Service, over 66,000 ac of national wildlife refuges managed by the Fish and Wildlife Services, about 673,000 ac of lakes managed by the U.S. Army Corps of Engineers, two military bases, and 4.4 million ac of national forests managed by the Forest Service (fig. 1). National forests occupy about 10 percent of the area. Thirty-nine Assessment area counties contain at least 38,000 ac of national forest lands; 12 counties have at least 100,000 ac, and 4 contain at least 200,000 ac of national forest lands. State lands include 65 State parks, 32 wildlife management areas, historic sites, 2 National Guard areas, and many State natural, historic, and conservation areas.

Social and Economic Conditions and Trends

Population Growth

The human population of the Assessment area has grown rapidly in recent decades and continues to do so, at least in metropolitan counties (fig. 5). Between 1970 and 1996, the population increased about 48 percent, while in Missouri, Oklahoma, Arkansas, and the Nation as a whole, the increases were only 15, 29, 31, and 30 percent, respectively. Recent (1990 to 1996) population growth in the Highlands is most strongly associated with metropolitan areas, high rates of in-migration, and the presence of national forest lands. In-migration of new residents contributed nearly 80 percent of the estimated population growth in the Assessment area as a whole and 83 to 98 percent of the growth in nonmetropolitan counties containing lands of one of the Highlands' national forests. (Two counties have lands of two national forests.)

Although the association of population growth with the presence of national forest lands may be coincidental, it is noteworthy that metropolitan counties containing parts of the Mark Twain or Ozark National Forest grew by more than 20 percent during this 6-year period. Similarly, the populations of metropolitan counties with Ouachita National Forest lands grew 10 percent, whereas metropolitan counties without national forest lands grew 7 percent. On the other hand, nonmetropolitan counties with 100,000 ac or more of national forest or other federally managed lands show the slowest population growth, on average, of Assessment area counties.

A few counties in the Highlands lost population over the last three decades. In Pulaski County, MO, cutbacks at Fort Leonard Wood resulted in the loss of nearly 30 percent of the county's population during that time. Seven counties saw net out-migration, and only one of these, Pulaski County, AR, had a sufficient natural population increase to produce net growth.

Communities

The geographic communities of the Assessment area include 695 municipalities and many unincorporated places. Nearly 97 percent of the municipalities in the region have populations of 10,000 or fewer, and more than half of the area's population lives in the open country. Only 24 cities had more than 10,000 people at the time of the 1990 census. Current estimates are that the Highlands now have 30 cities of that size.

As of 1990, 16 Assessment area counties were "retirement destinations," according to the Economic Research Service. Most of these counties are in the heart of the Assessment area, with a string of 15 of them extending in a north-south band from Benton and Morgan Counties in the Missouri Ozarks to Garland County in the Ouachita Mountains of Arkansas (fig. 6). Nine of the 16 retirement destination counties have national forest lands; at least 8 contain portions of large lakes.

Retirement-aged adults make up a significant segment of the population of the Assessment area. Seventeen percent of nonmetropolitan and 12 to 13 percent of metropolitan Assessment area residents in 1990 were over age 65.

Thirty percent or more of the land base in nine nonmetropolitan counties consists of Federal lands, making these counties particularly sensitive to Federal land policies. Four of these counties—and 32 others in the Assessment area—have persistent high levels of poverty.

Arkansas communities in the Highlands that depend upon the timber industry show no clear pattern of disadvantage in terms of poverty or annual per pupil expenditures on K–12 public education. When compared with other rural communities, timber- and national forest-dependent rural communities in Arkansas appear no less willing to invest in education than other communities. Annual Federal payments (including "25 percent returns") to the counties and school districts that have national forest lands apparently compensate for most effects of the reduced tax base

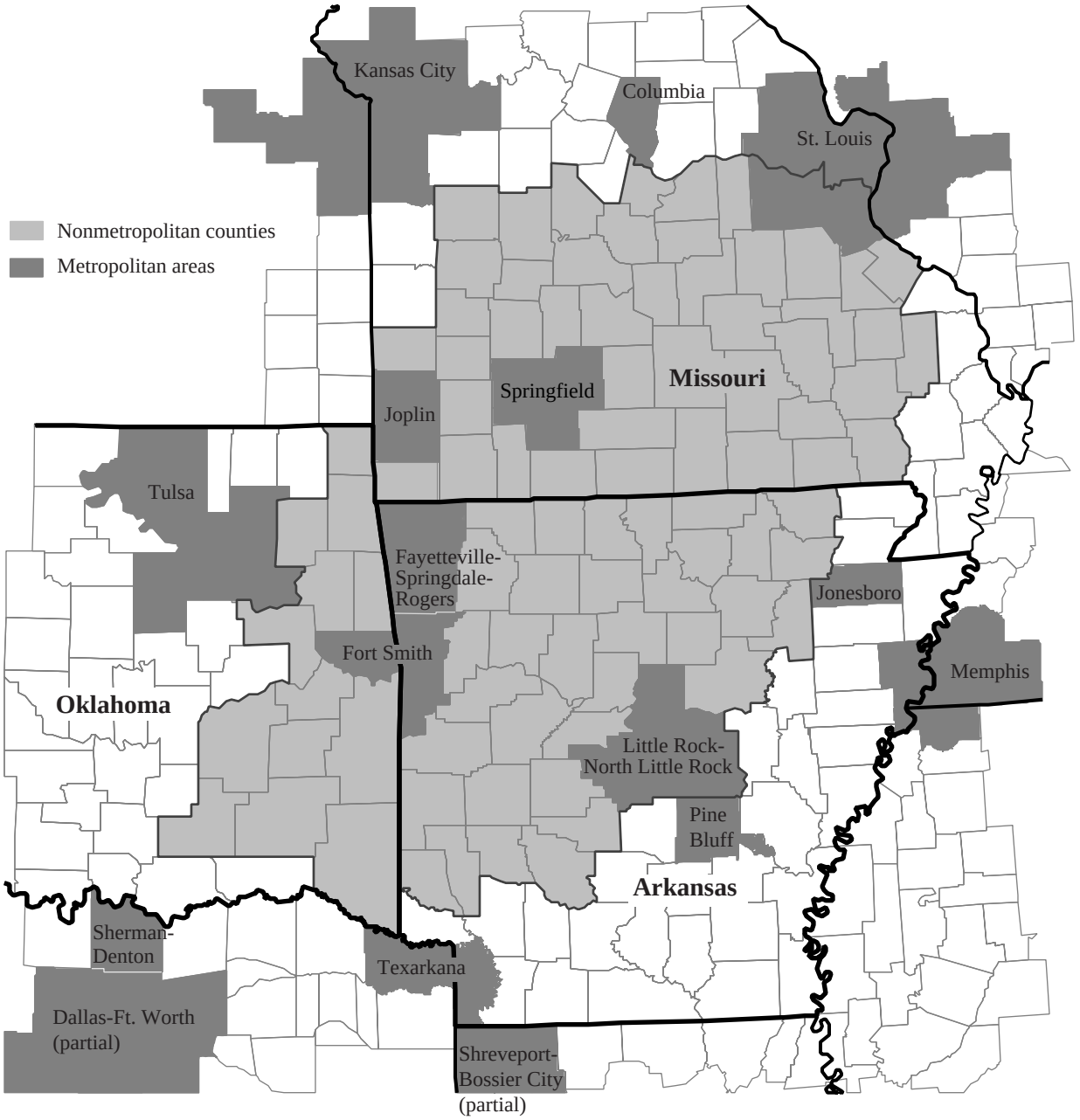


Figure 5—Metropolitan counties (dark gray) in the Assessment area tended to have the highest rates of population growth.

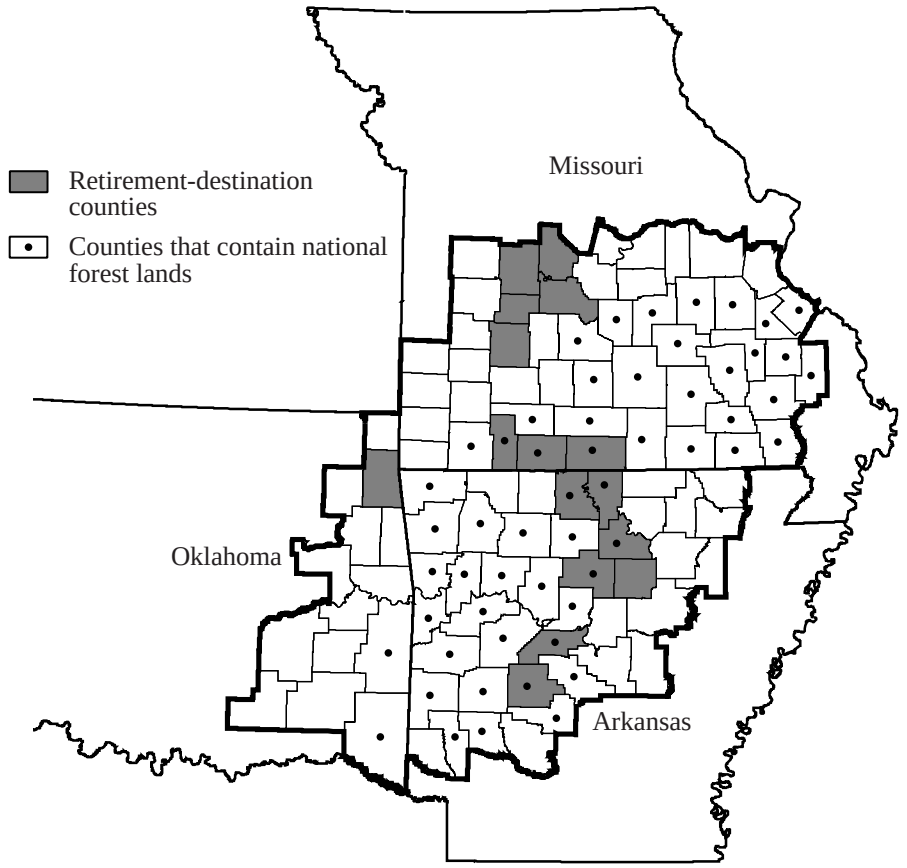


Figure 6—A string of 15 "retirement destination counties" (shaded) extends in a north-south band from Benton and Morgan Counties in the Missouri Ozarks to Garland County in the Ouachita Mountains of Arkansas.

attributable to the presence of these Federal lands. The same patterns may or may not hold true in the Oklahoma and Missouri communities of the Highlands.

Race and Hispanic Origin

The Assessment Team used the same categories as those used by the U.S. Bureau of the Census during the 1990 census (the race categories of White, Black, American Indian and Alaska Native, and Asian and Pacific Islander and the ethnicity categories of Hispanic and non-Hispanic). In 1990, 91 percent of the people living in the Assessment area were White, representing a much higher proportion of residents than in Arkansas (82 percent), Missouri (87 percent), Oklahoma (81 percent), or the Nation as a whole (76 percent). Generally, racial composition tends to be more homogeneous in counties containing national forest lands than in the other Assessment area counties.

Among those counties that do contain national forest lands, those with Ouachita National Forest lands appear to have the greatest degree of racial diversity: together, American Indians and Black Americans make up 5 percent of the metropolitan population and 10 percent of the nonmetropolitan population in "Ouachita counties." However, some of the nonmetropolitan "Ouachita counties" have very little diversity. The higher numbers of American Indians and Black Americans in the Ouachitas as a whole largely reflect the racial diversity of two southeastern Oklahoma counties (Le Flore and McCurtain) and three Arkansas counties (Hot Spring,

Howard, and Garland—the first two of which lie partially in the West Gulf Coastal Plain and contain less than 1,900 national forest acres).

Although the population of the Assessment area grew rapidly between 1970 and 1990, its racial and ethnic composition changed very little. The White total declined slightly as a percentage of the population, from 93 percent in 1970 to 91 percent in 1990. Black American totals also declined slightly (5.3 percent in 1970 to 5.2 percent in 1990). Other groups grew from 1.4 percent of the Assessment area population in 1970 to 3.6 percent in 1990.

There is evidence, however, that the ethnic diversity of the Assessment area increased in the 1990's. For example, the Bureau of the Census estimated in 1998 that the Assessment area Hispanic population grew 52 percent between 1990 and 1996. A special census of Washington County, AR, in 1996 showed a 435 percent growth in the Hispanic-American population between 1990 and 1996 (from 1,526 to 8,164 individuals).

Educational Levels

Overall, educational levels are relatively low in the Assessment area. In 1990, 37 percent of adults 25 years and older had not completed high school (or its equivalent), and 13 percent of teenagers (ages 16 to 19) were high school dropouts. Residents with low levels of education are more common in nonmetropolitan counties. In 14 nonmetropolitan Assessment area counties, clustered mainly on the eastern side of the Highlands, at least 45 percent of the adult population had less than a high school diploma.

Socioeconomic Well-Being

The overall level of socioeconomic well-being in the Assessment area is relatively low. In 1989, median household incomes in the area were almost $11,000 less than the national median of $30,056. Individual poverty rates in the Assessment area (17 percent) were greater than poverty rates in Missouri (13 percent) and the Nation (14 percent), equal to the poverty rate in Oklahoma, and lower than the rate in Arkansas (19 percent). Assessment area workers, especially those living in nonmetropolitan counties with national forest lands, faced higher unemployment rates than the Nation as a whole (7.8 percent compared to 6.3 percent in 1990).

The Economic Research Service classifies 37 nonmetropolitan counties in the Assessment area as having "persistent poverty" (high rates of poverty in each of 4 years: 1960, 1970, 1980, and 1990). Nearly half of the 49 nonmetropolitan "national forest counties" and one-third of the 42 nonmetropolitan counties with no national forest lands are persistent poverty counties (fig. 7). In nonmetropolitan counties, persistent poverty appears most often in southeastern Missouri (15 counties), north-central Arkansas (9 counties), and southeastern Oklahoma (6 counties). The 24 persistent poverty counties in southeastern Missouri and north-central Arkansas include 12 of the 14 counties in which 45 percent or more of the adult population have less than a high school education; 19 of these 24 persistent poverty counties include national forest lands.

Retirement pensions and Social Security income provide a slightly larger portion of aggregate income in the Assessment area than in the three States (13 percent versus 11 to 12 percent). These two sources of income are most important (at 15 to 18 percent of total income) in nonmetropolitan counties with national forest lands.

Economic Output, Employment, and Employee Compensation

Of the 10 major economic sectors in the Assessment area, manufacturing has the largest share of output and employee compensation. This sector produces 33 percent of total output, employs 16 percent of all workers, and pays 22 percent of all employee compensation in the area. The trade and services sectors each employ more people but provide less employee compensation than manufacturing (table 1). Average annual wages are highest in the transportation and mining sectors, followed by manufacturing and a category that combines government and special industries.

Between 1977 and 1993, total industrial output in the Assessment area grew 53 percent above inflation, and employee compensation grew 40 percent above inflation. The construction sector had the greatest increase in total output—291 percent—followed by the services sector (at nearly 192 percent). Concomitant with these

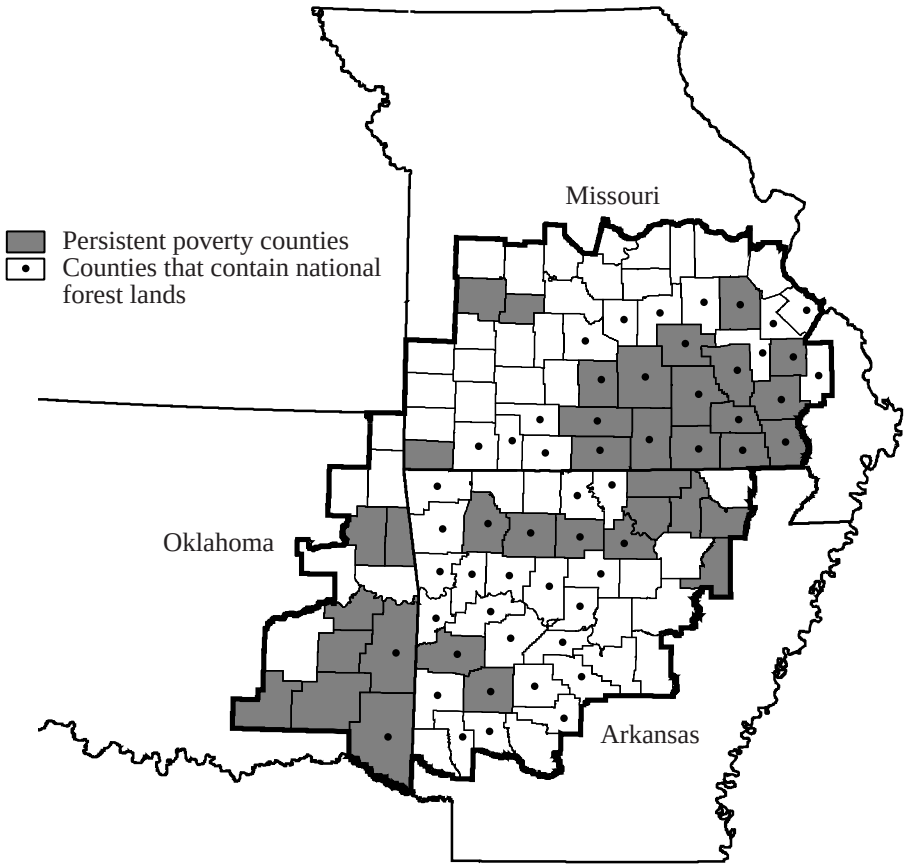


Figure 7— The Economic Research Service classifies 37 nonmetropolitan counties in the Assessment area as having "persistent poverty" (high rates of poverty in 1960, 1970, 1980, and 1990). Nearly half of the 49 nonmetropolitan "national forest counties" have persistent poverty.

Table 1—Industrial output, employment, and employee compensation across selected industrial sectors of the Assessment area, 1977 and 1993, and percent change in these measures from 1977 to 1993

	Industrial output			Employment (jobs)			Employee compensation		
Industrial sector	1977	1993	Change	1977	1993	Change	1977	1993	Change
	- - - - Million dollars - - -		*Percent*			*Percent*	*- - - Million dollars - - -*		*Percent*
Agriculture and fisheries	2,553.3	5,813.0	127.7	30,307	127,527	320.8	167.8	422.4	151.7
Mining	606.2	912.4	50.5	6,917	4,886	-29.4	192.0	144.0	-25.0
Construction	3,607.0	14,114.6	291.3	80,621	139,972	73.6	1,307.2	2,259.9	72.9
Manufacturing	18,941.8	39,836.9	110.3	314,490	304,441	-3.2	4,421.2	8,025.6	81.5
Transportation	3,830.9	9,349.6	144.1	65,939	89,604	35.9	1,154.2	2,789.8	141.7
Trade	5,452.1	12,725.7	133.4	236,291	397,244	68.1	2,347.1	6,065.0	158.4
Finance	5,436.6	13,388.7	146.3	49,744	85,422	71.7	657.7	1,728.4	162.8
Services	6,013.8	17,532.1	191.5	286,688	437,157	52.5	2,483.2	7,019.9	182.7
Government and special industries[a]	3,035.4	8,107.5	167.1	236,242	299,831	26.9	2,758.0	7,652.8	177.5
Total	49,477.1	121,780.5	146.1	1,307,239	1,886,084	44.3	15,488.4	36,107.8	133.1

[a] Government and special industries sectors are combined due to differences in sector definitions between 1977 and 1993; only the combined totals of the two sectors are comparable.

increases and with regional population growth, the number of jobs in the Assessment area rose 44 percent. Jobs increased at least 35 percent in every major sector except manufacturing (3.2 percent decline) and mining (29.4 percent decline).

The mining, forest products, and recreation-tourism industries generate most of the tangible economic output from public lands. Of these, only mining is considered a major economic sector, and the contributions of the other two have to be estimated based on activities in several major sectors. Because these three industries have special importance for public land management (and especially national forest management), each will be discussed in more detail.

Minerals Industry

The minerals industry accounts for 5 percent of the total output, 2.2 percent of all employment, and 3.4 percent of the employee compensation in the Assessment area. Approximately 10,500 people within the Assessment area work directly in the minerals industry. Twenty-one counties had double the average share of output, employment, and/or employee compensation from the minerals industry (fig. 8); in other words, the proportion that the minerals industry contributed to these counties' output, employment, and/or compensation was at least twice the average for the Assessment area.

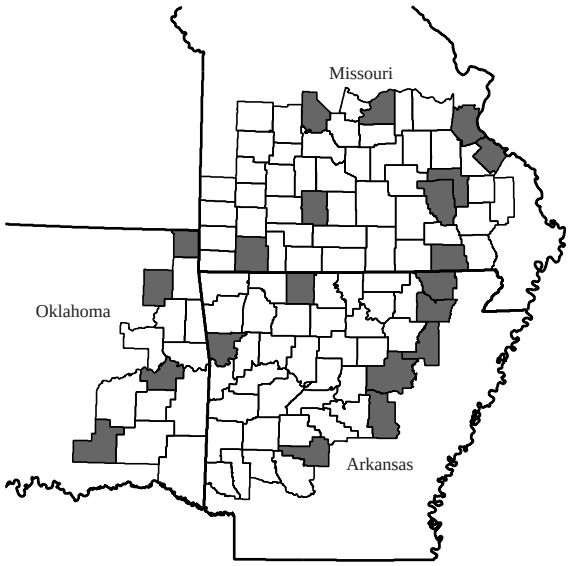


Figure 8—The proportion of the total output, employment, and/or compensation that the minerals industry contributed in 21 counties (shaded) was at least twice the average for the Assessment area.

Forest Products Industry

In the Assessment area, 5 percent of the industrial output, 3 percent of the employment, and 3.4 percent of the employee compensation are directly attributable to the forest products industry. Thirty-five of the 107 counties in the Assessment area have at least double the area average output, employment, and/or employee compensation from the forest products industry (fig. 9). On average, 15.7 percent of the output, 8 percent of the employment, and 11 percent of the employee compensation in these counties were from the forest products industry. The Assessment area accounts for about 2.3 percent of the Nation's output of forest products.

Travel and Tourism Industry

The travel industry supports 5.7 percent of the output, 7 percent of the employment, and 4.6 percent of the employee compensation in the Arkansas and Missouri portions of the Assessment area (comparable data for Oklahoma are not available). In 1996, travel expenditures in the Assessment area counties of Arkansas and Missouri totaled $9 billion and accounted for nearly 167,000 jobs. A 1995 study for Oklahoma indicated that expenditures related to travel totaled over $3 billion. Although all of this activity obviously is not recreation- or tourism-related, significant portions of it are.

Examining only the counties that have at least twice the Assessment area's average percent of total output, employment, and/or employee compensation yields 23 counties that have high concentrations of travel-related employment, output, or income (fig. 10). The travel industry's share of the economy in these counties averages 25.5 percent of industrial output, 28.9 percent of employment, and 24.7 percent of employee compensation. Combined, these counties—4 in Arkansas and 19 in Missouri—account for almost half the total travel-related output, employment, and employee compensation in the Arkansas-Missouri portion of the Assessment area. Taney County, MO, where Branson is located, has an incredible 83.7 percent of its jobs related to travel. In Camden, Hickory, and Stone Counties in Missouri, more than 40 percent of the jobs

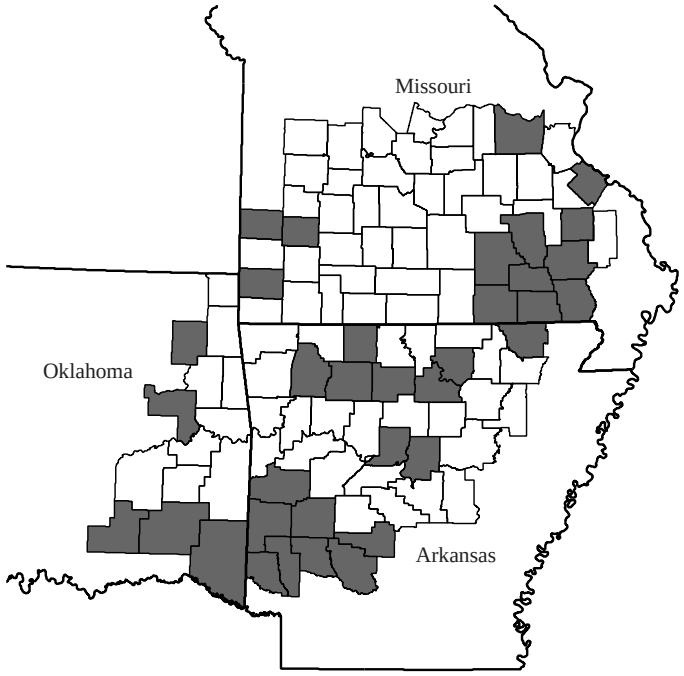


Figure 9—In 35 counties (shaded), an average of 15.7 percent of total output, 8 percent of employment, and 11 percent of total employee compensation was from the forest products industry.

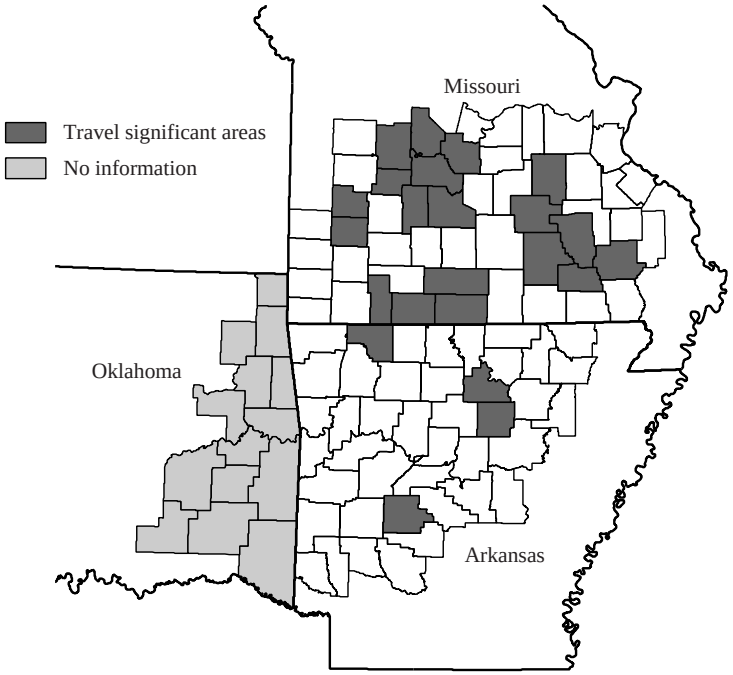


Figure 10—In 23 counties (shaded dark), the travel industry's share of the economy averages 25.5 percent of industrial output, 28.9 percent of employment, and 24.7 percent of employee compensation.

are associated with the travel industry. Carroll County, AR, has the highest percentage (20 percent) of travel-related employment in that State.

Heritage Resources

Archeologists have documented approximately 14,040 archeological sites within the Highlands' three national forests. These sites are estimated to represent less than one-third of the total number of sites on these Federal lands. Prehistoric sites range from small isolated finds of single artifacts to extensive quarries; some sites are 12,000 years old. Historic sites are also highly varied and numerous, ranging from cemeteries, fire towers, and home sites to entire towns that were settled and then abandoned during the 20th century (fig. 11).

Range Resources, Special Uses, and Special Forest Products

Of the more than 14 million ac of grazing land in the Assessment area, only about 4.5 percent (743,000 ac) consist of Federal lands. More than 90 percent of the national forest range consists of grazed woodlands (principally on the Ouachita National Forest) that have low forage value; the remaining 10 percent of range (principally on the Mark Twain National Forest) consists of natural openings and improved pasture. The number of individuals that hold permits to use national forest range declined 67 percent from 1987 through 1996, and range use itself dropped 63 percent.

Various "special uses" are permitted on the Highlands' national forests to accommodate individual and community needs, including economic development. In 1996, there were more than 2,000 special uses under permit on the Highlands' national forests, generating fee revenues of nearly $330,000.

Firewood remains in demand on all three national forests in the Highlands. Firewood availability on the Ouachita National Forest, however, has declined by about 62 percent since 1992.

There is a large and increasing demand for wild plants used in herbal dietary supplements and medicines. Arkansas accounts for 2 percent and Missouri for 3 percent of total U.S. production of wild ginseng. The Ozark National Forest permits limited harvesting of ginseng; otherwise, the three national forests have not been a significant source for herbal products. Small amounts of grapevine, pine knots, sassafras, lichens, and acorns are harvested under permit. The total revenue generated by the sale of permits to gather special forest products on the three national forests in 1996 was about $32,000.

Figure 11—Public lands harbor many historic sites, including cemeteries, fire towers, home sites, and Civilian Conservation Corps (CCC) structures such as cabins and lodges.

Impacts of National Forest Programs on the Highlands' Economy

In 1996, the gross regional product (sum of all incomes, less indirect business taxes) for the Highlands was $61,600 million. National forest programs, payments to counties, and expenditures accounted for almost 1 percent ($557.4 million) of this total. National forests directly influence nearly 17,000 jobs, which is also slightly less than 1 percent of Assessment area employment (approximately 1.9 million jobs). Naturally, the economic impacts of national forests are felt most closely in those counties that either have significant amounts of national forest lands or are close to ones that do.

Of the three principal national forest programs affecting the Highlands' economy (minerals, recreation, timber), timber has the greatest overall influence on employment, employee compensation, and total income when the three forests are considered together (fig. 12). However, the relative economic importance of

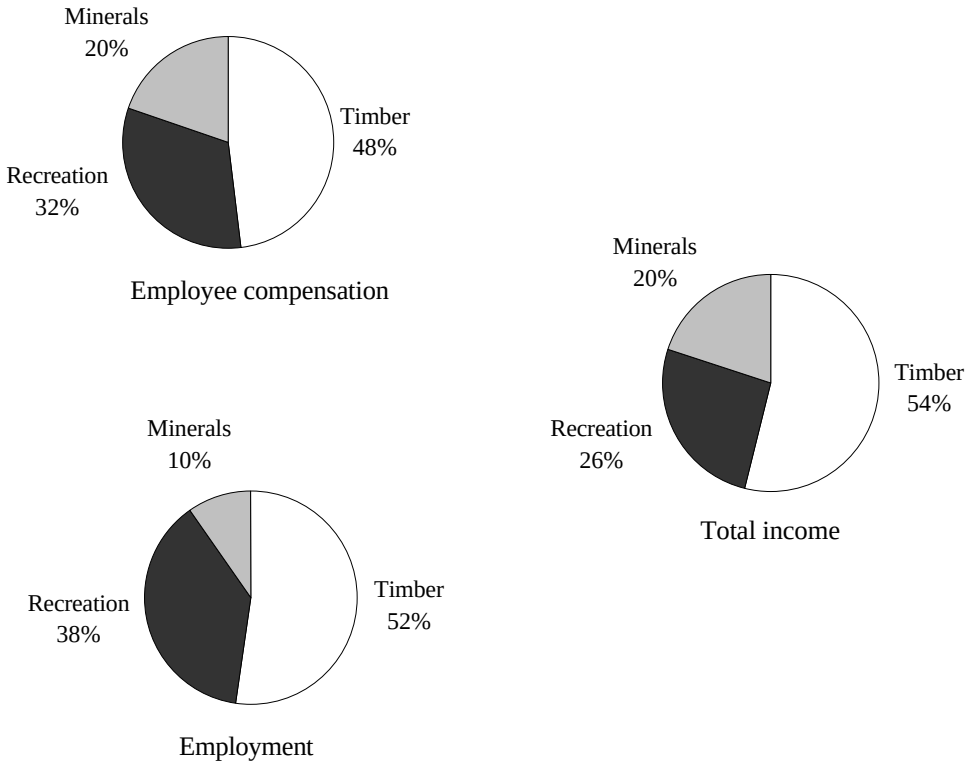


Figure 12—Although the economic importance of minerals, recreation, and timber (the three principal national forest programs that generate revenue) varies significantly among the three Highlands forests, timber has the greatest overall influence on employment, employee compensation, and total income when the forests are considered together.

these resource programs varies significantly among the forests.

Using 1996 as a typical year, national forest timber harvesting directly affected 8,052 private sector jobs and generated $261.3 million in total industry income and $118.8 million in employee (non-Forest Service) compensation. Recreation directly affected 5,848 jobs in the Assessment area and generated about $188 million in total income and $74.4 million in employee compensation. Minerals programs affected 1,514 jobs and generated $91.6 million in total income and $47.7 million in employee compensation. In addition, national forest revenues in fiscal year 1996 yielded $6.6 million in payments to States and counties in the Assessment area.

Recreation

Settings

State and national parks, national forests, national wildlife refuges, and Army Corps of Engineer lands and waters occupy about 13 percent of the Highlands and provide the principal settings for many kinds of outdoor recreation. The three national forests, covering 4.4 million ac (85 percent of the public lands in the Assessment area), are the main providers of dispersed recreation opportunities such as primitive camping, hunting, and trails—offering, for example, about 63 percent of the trail miles in the Assessment area (fig. 13). Recreation opportunities on these national forests are principally in settings the Forest Service classifies as “roaded natural” (75 percent) or “semiprimitive” (20 percent); very few “primitive” settings are available on national forests or elsewhere in the Highlands.

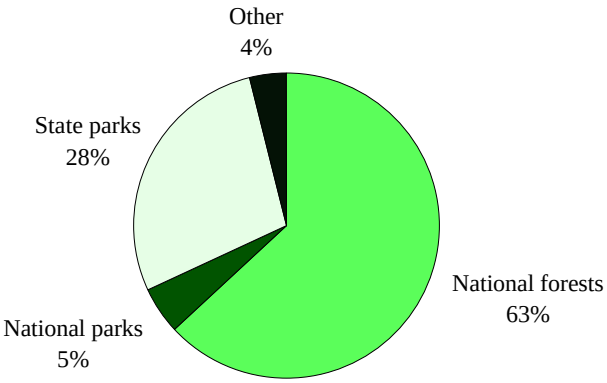


Figure 13—National forests provide about 63 percent of the trail miles in the Assessment area.

Developed recreation sites are more common on other public lands and on private lands. For example, the Army Corps of Engineers provides one-half and State park agencies provide nearly one-third of the developed campsites in the Assessment area, while national forests supply about one-sixteenth. Private operations account for the remainder (about one-eighth) of the campsites.

The condition of many recreation facilities on public lands is declining due to their age and heavy use. Lack of adequate funds to maintain and repair existing facilities is a widespread concern among land managers in the region. Recreation overuse, particularly in the categories of off-road vehicle driving, dispersed camping, and river use, is occurring in some areas, resulting in resource damage and conflicts among users.

Because they provide many of the settings for outdoor recreation, public lands are important to maintaining and enhancing a strong tourism industry. Private lands are also important to the Highlands' tourism industry, if for no other reason than that they influence the scenic quality of large parts of the area. The nonindustrial private forest (NIPF) lands account for between 65 and 85 percent of all timberlands in three of the Highlands' four ecological sections—the Ozark Highlands, Boston Mountains, and Arkansas Valley. In the Ouachita Mountains, forest ownership is almost evenly split among industrial forest lands, national forests, and NIPF lands. Some tourism opportunities span all three types of ownership, notably the nine national forest and State scenic byways in the Assessment area. More than 7 million people travel over these byways each year.

Wilderness, Wild and Scenic Rivers, and Other Congressionally Designated Areas

Congress has established nearly 240,000 ac of wilderness in the Highlands' national forests and along the Buffalo National River. Federally designated wilderness in the Highlands represents 4.4 percent of all national forest lands and about 5 percent of the total Highlands land area managed by the Forest Service and the National Park Service combined. Wilderness areas are found in all four ecological sections of the Highlands.

Congress has recognized about 523 mi of rivers in the Highlands for their exceptional values by designating them national rivers or components of the National Wild and Scenic Rivers System (fig. 14). More than 2,000 additional miles of rivers may merit special designation for their recreational or other outstanding values but have not yet been the subjects of complete evaluations to determine their suitability for inclusion in the National Wild and Scenic Rivers System.

Finally, Congress has designated the Winding Stair Mountain National Recreation Area and several adjacent scenic and botanical areas (altogether about 83,422 ac) on the Ouachita National Forest in Oklahoma.

Draw Area and Demand for Recreation

Approximately 57 million people—21 percent of the U.S. population—live within a 1-day drive of some of the Highlands' outdoor recreation opportunities. These 57 million people, then, live in the Highlands' "draw area" (fig. 15). Residents of the draw area exceed the national average in percent of population participating in every major category of outdoor recreation available in the Highlands. More than 90 percent of the draw area population participates in activities associated with viewing and learning about nature and human history such as sightseeing, birdwatching, and wildlife viewing. Approximately 40 percent participate in fishing and outdoor adventure activities such as hiking or off-road driving. About 30 percent participate in camping, and 14 percent participate in hunting.

Demand for nearly all categories of recreation activity is expected to increase in the next decade (fig. 16).

Figure 14—Richland Creek in the Arkansas Ozarks is one of 11 National Wild and Scenic Rivers in the Highlands.

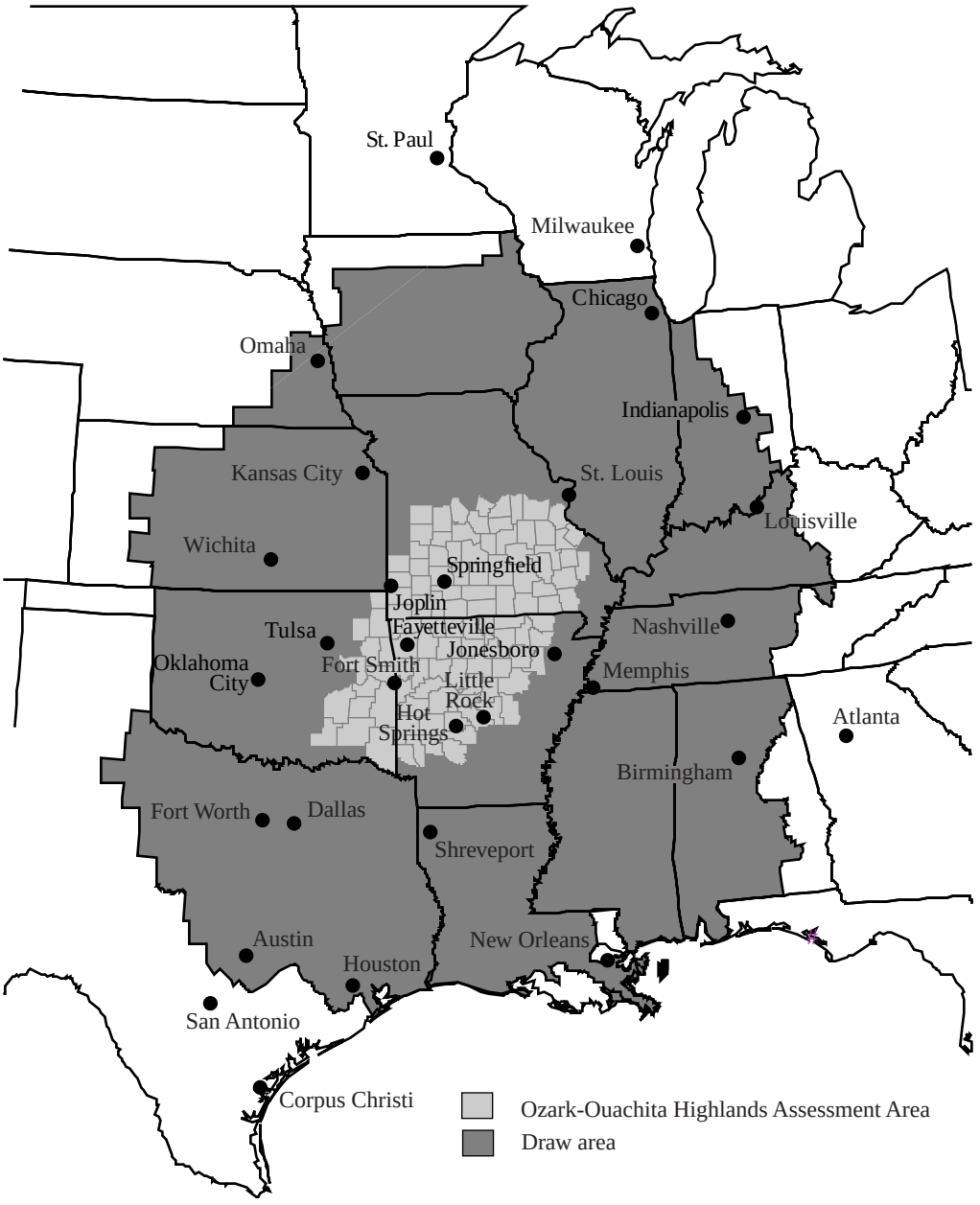


Figure 15—About 57 million people live within a 1-day drive of the Assessment area; residents of this "draw area" exceed the national average in percent of population participating in every major category of outdoor recreation.

Figure 16—Horseback riding is one of many recreation activities expected to increase in the Highlands between 2000 and 2010.

Nationally, the largest projected increases are for activities involving visits to historic sites and beaches (and other water sites), biking, and sightseeing.

Timber

In terms of timber volume, the forests of the Highlands are predominantly hardwoods (over 14 billion cubic feet of growing stock and over 38 billion board feet of sawtimber). Softwood—especially pine—volumes are also substantial (about 7 billion board feet of growing stock and over 24 billion board feet of sawtimber). More than two-thirds of the hardwood volume occurs on NIPF lands, while softwood volume is fairly evenly distributed among timber industry, national forest, and NIPF lands. Both growing-stock and sawtimber inventories have increased in the Arkansas and Oklahoma portions of the Highlands over the last decade. (Comparable data for Missouri were not available.)

NIPF owners hold 69 percent of the timberland in the Highlands; national forests account for 15 percent, other public lands for 5 percent, and forest industry for 12 percent of the timberland acres. Across all subregions of the Assessment area except Oklahoma, NIPF lands have the largest proportion of higher grade hardwoods relative to the other ownership categories

Figure 17—Although national forests account for 41 percent of the total softwood-sawtimber volume in the Assessment area, they account for only 20 percent of softwood-sawtimber removals.

while the national forests have the greatest share of the higher grade softwood sawtimber volume.

National forests account for 41 percent of the total softwood-sawtimber inventory but only 20 percent of sawtimber removals in the Assessment area (fig. 17). In contrast, forest industry accounts for 20 percent of softwood-sawtimber inventory but 40 percent of removals (while NIPF lands account for 35 percent of inventory and 39 percent of removals). Sawtimber-size stands occur on 58 percent of the national forest timberland acreage in the Assessment area and from 28 to 48 percent of timberlands in other ownership categories.

The majority (64 percent) of large diameter (greater than 20 inches in diameter at breast height) hardwood volume occurs on NIPF lands.

Up to 15 percent of the potentially harvestable volume of timber on private land may be unavailable due to physical constraints such as wet sites, steep slopes, and low volumes. On the three national forests, from 59 to 79 percent of the land is classified as suitable for timber production based on suitability definitions that exclude acres for wilderness, administrative sites, areas of low productivity, and areas allocated to other resource management categories.

In general, inflation-adjusted prices for Highlands' timber rose between 1988 and 1994, implying an increasing scarcity of timber resources. Between 1992 and 1995, the three Highlands States increased their share of the total U.S. lumber production from 5.5 percent to 6.8 percent. Since 1988, these three States also claimed an increasing proportion of the Nation's investments in the furniture and lumber industries. Largely due to the decline in timber harvests from western forests, national forest timber sold in the

Highlands represents an increasing percentage of total U.S. national forest timber sales. Between 1991 and 1995, the Highlands' share of total national forest "green" (not salvage) timber sales increased from 3 percent to 10 percent.

New hardwood chip mills have recently led to increased hardwood-pulpwood removals—a 135 percent increase between 1994 and 1995—particularly in Arkansas. Due to fluctuating demand over the preceding decade, the overall percentage increase in average annual removals since 1988 was 65 percent. These increases should lead to higher prices, providing income to local landowners and possibly forcing other competing industries to pay more or seek alternate sources.

The Assessment area contains 12 percent of the South's timberland but only 5 percent of southern softwood volume and 9 percent of southern hardwood volume. However, relatively low removals rates (3 percent of southern softwood and 6 percent of southern hardwood removals) will continue to attract new and expanded wood-using industries to the area.

Favorable growth-to-removals ratios indicate that the softwood inventory in the Highlands is increasing. Projections to 2020 show increasing softwood harvests on private lands in the Highlands—more than double the rate experienced in 1990. Total softwood harvests in the Highlands are projected to increase at rates greater than the South as a whole (fig. 18).

The currently favorable growth-to-removals ratio for hardwoods in the Highlands is projected to narrow and be about equal by 2020 as growth remains stable and removals increase, especially in the Ozarks (fig. 19).

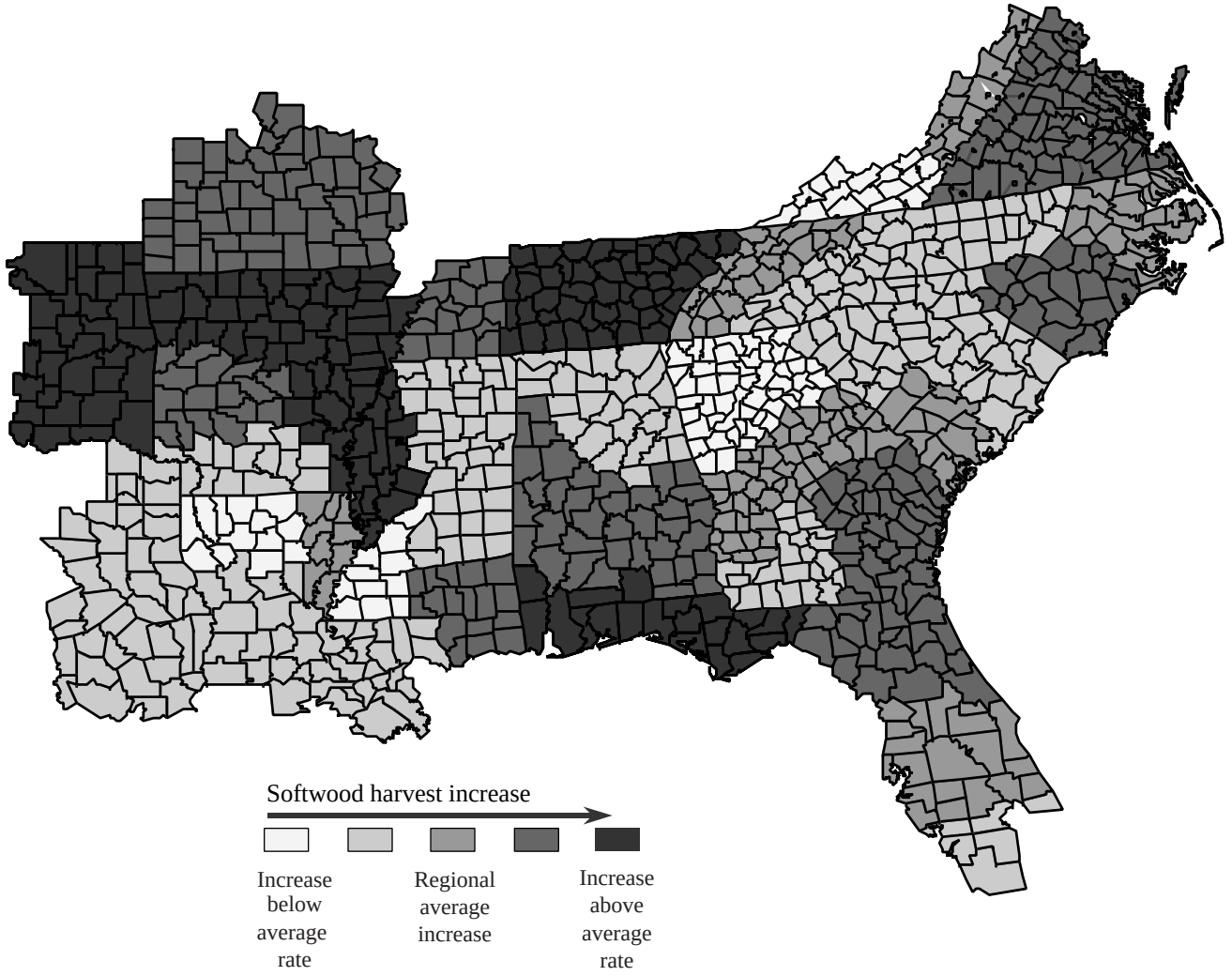


Figure 18—Projections to 2020 show increasing softwood harvests on private lands in the Highlands—more than double the rate experienced in 1990.

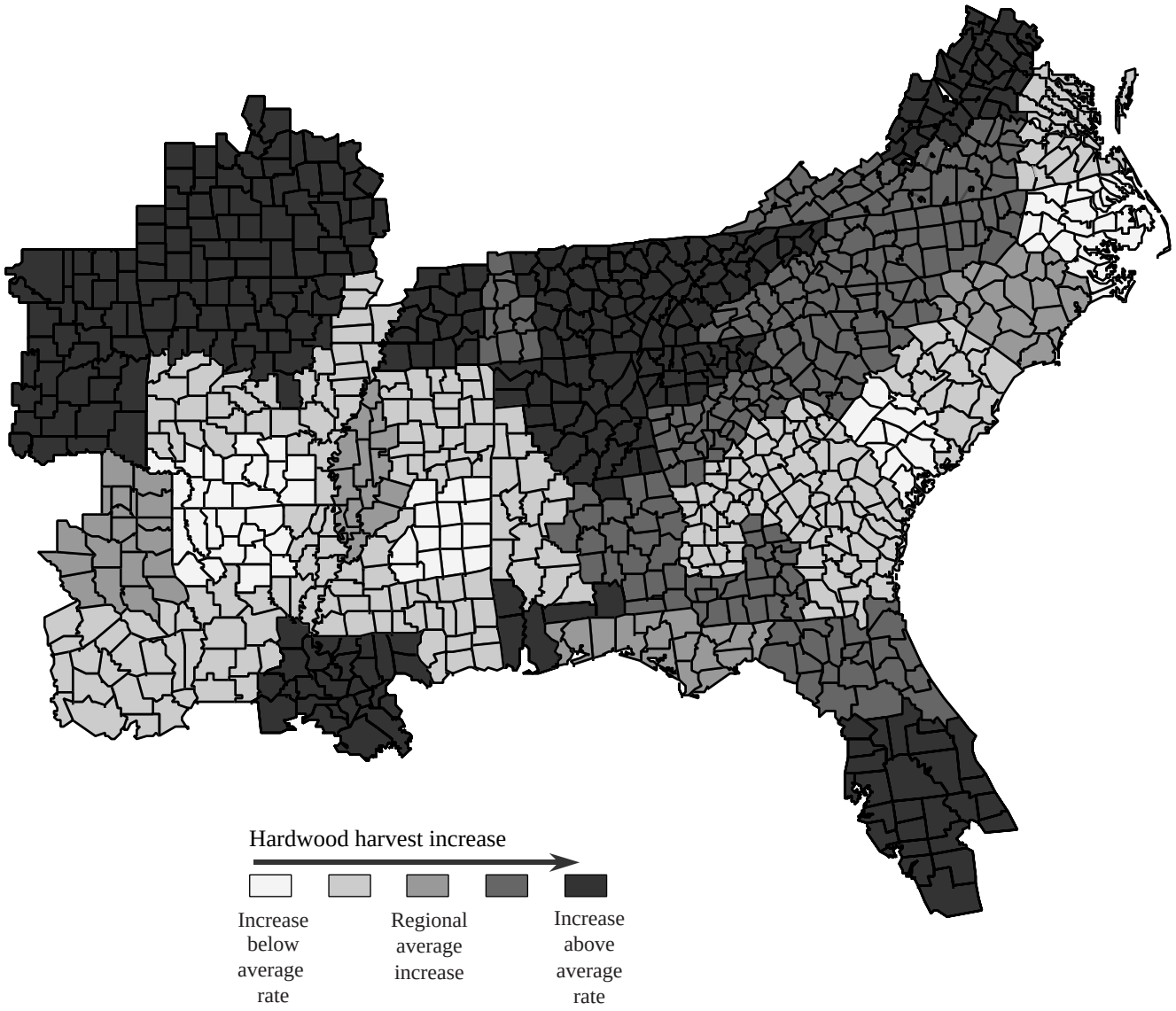


Figure 19—Despite projected increased harvesting of hardwood trees in parts of the Highlands, hardwood inventory in 2020 is projected to be greater than current levels.

Nonetheless, by 2020 hardwood inventory is still projected to be greater than current levels.

Minerals

Of 76 known minerals and mineral materials within the Assessment area, 33 are currently being mined. The Assessment area contains the top 10 production sites in the United States for 14 mineral commodities. The portion of Missouri within the Assessment area contains the largest concentration of lead deposits in the world. Mines located there are the number one producers of lead in the United States and until recently were also the world's major lead producers. Between 75 and 80 percent of U.S. lead production comes from the Mark Twain National Forest (fig. 20).

The Ouachita Mountains are the only source for electronic grade, high quality quartz in North America. All of the Nation's production is from the Ouachita National Forest in Arkansas. The Ouachita Mountains and the Ouachita National Forest are major world

Figure 20—Between 75 and 80 percent of the Nation's lead production comes from the Mark Twain National Forest. (Photo courtesy of Doe Run Mining Company, Viburnum, MO.)

producers and the leading U.S. producers of quartz crystal for aesthetic and jewelry uses. Missouri is the leading U.S. producer of fire clay, much of which is mined from within the Assessment area.

Sixty percent of the mineral resource extraction operations (mining and processing plants) within Arkansas, Missouri, and Oklahoma occur within the Assessment area, accounting for approximately $1.2 billion in mineral value in 1996. Coal from the Oklahoma portion of the Assessment area is used to generate power for 150,000 homes in eastern Oklahoma.

In 1996 alone, extraction of mineral resources from the three national forests within the Assessment area generated almost $6 million in Federal revenue. The national forests within the Assessment area have a high potential for discovery of additional reserves of the minerals currently being mined on them and, in some cases, those mined in the past as well. For example, the Ozark National Forest has 66 producing gas wells in areas that have a high potential for additional development. The demand to access the national forests for mineral exploration is expected to continue and increase.

Finally, the Assessment area and its three national forests have unique geologic features that attract people from across the United States and throughout the world for research, education, rockhounding, and mineral collecting.

Public Attitudes, Values, and Opinions About Land and Resource Management

Opinion surveys indicate that the American public strongly supports the need to maintain healthy forests and environmental quality, although the concept of "healthy forest" is subject to a variety of interpretations. One version suggests that undisturbed old-growth forests are the best models of ecological health; another envisions vigorous, disease-free young trees growing in orderly plantations; and still another looks not to any particular stage of forest development but to how well key ecosystem functions are sustained.

Generally, the public accepts the idea that forests fulfill a variety of roles—from pristine wilderness to intensive tree farms—and that forest management objectives will differ among and within landowner categories (e.g., public, industrial, NIPF). Most respondents in public opinion surveys support the following ideas: (1) forests should be managed for multiple uses; (2) forests should provide a range of goods, services, experiences, and values; and (3) public forests should not provide goods and services at the expense of long-term forest health and environmental quality (fig. 21).

Although some segments of the public have a strong interest in environmental issues and public land management, few people have a good grasp of land management principles and practices or even know which agencies are responsible for managing public land. Most people responding to public opinion surveys, however, seem to support the concept of multiple-use management of the national forests—managing for recreation, timber, watershed, range, and fish and wildlife values in ways that are as harmonious and coordinated as possible and do not impair the productivity of the land. (Wilderness, historic-cultural, and mineral resources are also important on many national forests.) However, there is no consensus about what the proper balance or mix of uses and values should be.

In various surveys, 40 to 50 percent of the respondents disapproved of timber cutting for wood products on public lands. However, if environmental protection

measures were listed as conditions or the management objective included benefits to wildlife and/or scenery, as many as 70 percent of the respondents tended to be in favor of such timber harvests. A study in Missouri suggests that 40 to 50 percent of the population may be opposed to logging regardless of how or where it takes place.

The public expects the Forest Service to take a scientific approach to managing the national forests, but they also want the agency to encourage public participation in decisionmaking and monitoring. One study on the Ouachita National Forest suggests that many people believe the Forest Service gives too much attention to environmental and timber industry interest groups and too little to the "ordinary citizen."

Results of an Arkansas survey indicated that NIPF landowners have strong interests in a variety of environmental issues. Their stated reasons for owning forest lands seem heavily weighted in favor of aesthetic and environmental values. A large percentage of such landowners expressed no intention of selling timber from their lands.

A majority of respondents to a survey conducted in Arkansas in the mid-1990's felt that water pollution, littering, clearcutting, agricultural waste, and disposal of hazardous materials were environmental problems in their State. Few identified mining of public land, damming of rivers, or destruction of wetlands as environmental problems. In Missouri, where 67 percent of the survey respondents in 1966 said they were "environmentalists," environmental issues paled in importance to concerns about crime, education, employment, and the economy.

Although it is difficult to estimate how many people in the Highlands believe private property owners face imminent threats of "takeovers" by United Nations-sponsored groups and/or government entities, those that hold such beliefs do so with great conviction. The public opinions voiced most often during Ozark-Ouachita Highlands Assessment Team working meetings in 1996 and 1997 were those having to do with perceived threats to private property and U.S. sovereignty.

Figure 21—Most citizens apparently approve of managing public forests for multiple uses as long as forest health and environmental quality are not compromised.

Aquatic Conditions and Trends

Surface Water Quality

The streams and lakes of the Ozark-Ouachita Highlands are among its most precious assets. This section describes the quality of surface water in streams and lakes of the Assessment area. The discussion focuses on nutrients (various forms of nitrogen and phosphorus); suspended sediment and suspended solids are discussed beginning on page 26.

Natural sources of nutrients in streams include: (1) fixation of atmospheric nitrogen by plants and bacteria, (2) deposition of atmospheric nitrogen from lightning, (3) dissolution of rocks or minerals, and (4) dissolution of soil organic matter and decaying plants and animals. Sources of nitrogen and phosphorus originating from human activities include sewage and septic tank discharges, fertilizer applications, and animal waste.

Background concentrations of nitrogen and phosphorus in streams are generally low because dissolved forms of the two elements are assimilated rapidly by plants and bacteria. Aquatic vegetation, particularly algae, requires nitrogen and phosphorus to grow. When concentrations of these nutrients in streams or lakes increase beyond normal levels, they can contribute to a dense growth of algae (algal blooms). Bacterial decomposition of dead algal cells after an algal bloom can deplete dissolved oxygen in the water body and negatively affect aquatic life (e.g., kill fish).

Data analyzed by the Aquatic Team for the period 1970 through 1990 show that concentrations of nitrogen and phosphorus forms and suspended solids did not change substantially during the study period at most stream sites in the Ozark Plateau. The same was also true of streams in the Arkansas Valley and Ouachita Mountains for measurements taken from 1975 through 1995 (fig. 22). In most parts of the Highlands, water samples from stream sites near sewage treatment plants had higher median concentrations of nitrite plus nitrate, ammonia, total nitrogen, and total phosphorus than any other type of site.

Within the Arkansas Valley, Boston Mountains, and Ozark Plateaus, nitrite plus nitrate concentrations at stream sites increased significantly with more intensive uses of land (e.g., acres of "forest-pasture mix" had higher concentrations than did "forest" acres). Where more intensive uses of land occurred in the Springfield and Salem Plateaus, Arkansas Valley, and Ouachita Mountains, ammonia concentrations in streams generally increased significantly. Within basins that have significant "agriculture" land use, total phosphorus concentrations were highest at stream sites in the Arkansas Valley where land was used for a mix of agriculture and forest activities. Concentrations of suspended solids were highest at stream sites in the Osage Plains (just outside the Highlands).

State monitoring reports from the mid-1990's identified more than 5,500 miles (mi) of Highlands' streams that exhibit varying degrees of impairment of their beneficial uses. The predominant sources of impairment of water quality within the Assessment area are agriculture (36.1 percent), "unknown" (10.9 percent), and mining (10.2 percent). About 133 mi, or 2.3 percent of the total impaired stream miles, occur within national forest boundaries. The sources of impairment for stream segments within national forest lands include agriculture, road construction, and silviculture.

At the opposite end of the scale, there are 4,113 stream miles of extraordinary, ecologically sensitive, and legislatively designated waters within the Assessment

Figure 22—In stream sample sites within the Highlands, concentrations of nitrogen, phosphorus, and suspended solids did not change substantially over 20-year study periods.

area. Seventeen percent of these miles occur on or immediately adjacent to national forests.

In addition to examining information concerning individual streams and lakes, the Aquatic Team reviewed available assessments of water quality at the scales of watersheds and river basins. The Assessment area is drained by 10 major river basins, each of which is subdivided into watersheds (fig. 23).

In an assessment of the Continental United States, the Environmental Protection Agency (EPA) rated 24

Figure 23—The Assessment area is drained by 10 major river basins, each of which is subdivided into watersheds.

of the 50 watersheds in the Ozark-Ouachita Highlands as having "better water quality and low vulnerability to impairment." Nationwide, only 9 percent of all watersheds scored this highly. The Spring watershed at the intersection of Arkansas, Missouri, and Oklahoma had "serious water quality problems and high vulnerability to stressors." Two others—the South Grand and Fourche La Fave watersheds—had "serious water quality problems and low vulnerability to stressors." Overall, however, watersheds within the Assessment area generally seem to have better water quality and less vulnerability than is typical for the Continental United States. National forest lands are present in 9 of the 10 basins and 34 of the 50 watersheds.

Lakes play many important social, economic, and environmental roles in dozens of communities and even whole counties in the Highlands (fig. 24). Each State submits a biennial assessment of the water quality of its lakes, including their trophic status. Trophic status refers to the degree of eutrophication of a lake (defined in the following paragraph) and provides insight into the lake's productivity and its future. In natural lakes, a correlation exists between the age of a lake and its trophic status. Reservoirs, because of their generally higher inflow and outflow rates, do not function in the same manner as natural lakes, but determining their trophic status does assist in understanding water quality problems affecting them.

Eutrophication is a cumulative process brought about by (1) agricultural runoff, (2) sewage and industrial effluents, and (3) natural nutrients (such as leaves and fallen trees). These inputs support increased algal and other aquatic plant growth and gradually fill lakes with sediment and decaying organic matter. Trophic status describes how far a particular lake has advanced in the eutrophication process, as described by the following classes:

- Oligotrophic: lakes that receive low levels of nitrogen, phosphorus, and other nutrients and thus have little algae or other aquatic plant growth;
- Mesotrophic: lakes that have received somewhat more nutrients and have greater aquatic plant growth.
- Eutrophic: lakes that have accumulated high levels of nitrogen, phosphorus, and other nutrients and thus are often very green due to large algal blooms.

Figure 24—Lakes and ponds cover less than 1 million acres within the Assessment area, but they have tremendous importance to the economies, lifestyles, and environments of the Highlands.

- Hypereutrophic (the most advanced stage of eutrophication): lakes that have received exceptionally large amounts of nitrogen, phosphorus, and other nutrients and consequently have very heavy growths of algae and other aquatic plants.

Trophic status is not necessarily a measure of lake use. People who use lakes for sightseeing, picnicking, swimming, or water skiing prefer oligotrophic lakes with good water clarity. Anglers prefer slightly more eutrophic lakes because they tend to have more species and larger fish due to enhanced aquatic plant communities.

Of the 28 Oklahoma lakes within the aquatic study area, 3 percent were classified as oligotrophic, 30 percent mesotrophic, 43 percent eutrophic, 17 percent hypereutrophic, and 7 percent (2 lakes) as silt dominated. Fort Gibson Reservoir was hypereutrophic-silt dominated, and Wister Reservoir was eutrophic-hypereutrophic. Oklahoma lakes were unusual with respect to their colloidal clay content. Resuspension of colloidal clays can produce very high levels of turbidity, a condition found in many Oklahoma lakes. In addition, most of Oklahoma's larger lakes were characterized by a large degree of horizontal mixing.

When the Aquatic Team assigned a trophic status to the 48 Arkansas lakes in the data base, 35 percent were classified as mesotrophic, 63 percent eutrophic, and 2 percent (1 lake) as hypereutrophic. Most of the mesotrophic lakes were borderline eutrophic, and at least half of the eutrophic lakes were borderline mesotrophic. Most of the large Federal reservoirs fell into these borderline situations while the smaller lakes fell into the higher value range of the eutrophic category (due to low flow-through). Lakes managed by the Arkansas Game and Fish Commission fall within the eutrophic category due in part to ongoing fertilization programs to improve fish production and shade out rooted aquatic weeds by increasing plankton production.

Within the Assessment area in Missouri, 13 percent of the lakes were classified as oligotrophic; these mostly occurred in the mountainous area of St. Francois County. Thirty-two percent of the selected Missouri lakes and reservoirs were classified as mesotrophic and 55 percent as eutrophic.

Ground Water Quality

Ground water is a vital resource in many parts of the Highlands, providing water for human consumption, irrigation, and cave life. The Springfield Plateau aquifer, the Ozark aquifer, and aquifers of the Ouachita Province generally provide water of excellent quality. Wide-ranging inorganic concentrations observed in aquifers in the Ouachita Province are indicative of both the province's diverse geochemical environments and, for some water quality measures, the influential land uses that are present. Background concentrations of nutrients in ground water of the Ouachita Province are low: nutrient concentrations were below detection limits in many ground water samples. Nitrite plus nitrate was detected in samples of ground water from sites in the Ouachita Province at concentrations ranging as high as 4.7 milligrams per liter (mg/L) as nitrogen, with a median of 0.16 mg/L.

Background concentrations of nutrients in the Springfield Plateau and Ozark aquifers are also low. Nutrient concentrations were below detection limits in many samples collected from sites in heavily forested areas. Nitrite plus nitrate was detected more often and in greater concentrations than any of the other nutrients. Values ranged from less than 0.05 to 25 mg/L as nitrogen, with a median of 1.6 mg/L. Concentrations were greater than background concentrations in many samples from these two aquifers and were positively correlated with the percent of agricultural land use around each site. Median nitrite plus nitrate concentrations generally were greater in samples from springs than in samples from wells. Springs are more susceptible to contamination from surface sources.

Point Sources of Water Pollution

Point sources include wastewater discharge pipes, stormwater drains, mine pits, smokestacks, and ditches. These are sources that deliver pollution via a single conveyance, in contrast with the more diffuse delivery of pollutants that characterizes nonpoint sources (discussed later).

Superfund Sites

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) was enacted in 1980 and amended by the Superfund Amendments and Reauthorization Act of 1986. These acts establish broad authority for the Federal Government to respond to problems posed by the release, or threat of release, of hazardous substances, pollutants, or contaminants. The CERCLA also imposes liability on those responsible for releases and provides the authority for the Government to undertake enforcement and abatement action against responsible parties. Within the aquatic study area, there are 15 Superfund sites—9 in Missouri, 4 in Arkansas, and 1 each in Kansas and Oklahoma. These sites are eligible for extensive, long-term cleanup funds under the Superfund program.

National Pollutant Discharge Elimination System Sites

About 136 point sources currently discharge treated wastewater into surface waters of the Assessment area. Many of these sources with National Pollutant Discharge Elimination System (NPDES) permits are considered major facilities based on their volume of discharge and pollutant loadings (concentrations of pollutants in discharged effluent). Four types of operations account for most of the point source discharges: sewage treatment plants, pulp mills, lead and zinc ore operations, and electrical services.

Of the four types of NPDES facilities that are ranked as "major," the greatest number are found in the Lower Neosho, Upper Black, and James River watersheds. Bull Shoals Lake watershed in the Upper White River Basin has the most NPDES sites in the Assessment area.

The majority of the permit sources with discharges greater than 1 million gallons per day (gal/d) are municipal treatment facilities. Approximately 200 sewage treatment plants discharge treated water into surface waters of the Ozark-Ouachita Highlands. Average daily flows from these facilities range from 1,000 to 2 million gal. Larger municipal sewage treatment plants include those of Springfield, MO, and Little Rock, AR.

Municipal Water Supplies

Municipal water supplies are essential to the well-being and growth of communities. They also affect aquatic resources. Water-supply reservoirs change hydrologic regimes and water quality, stop downstream movement of sediments, initiate downstream channel erosion, and influence downstream water temperatures. Therefore, municipal water supplies are regarded as point sources for some purposes. (Water withdrawals by municipal facilities in the Assessment area are discussed subsequently in the section entitled "Water Use.")

Toxic Releases

As in many other parts of the world, hundreds of toxic chemicals are stored, transported, used, and disposed in the Assessment area. Toxic chemicals include any chemical listed in EPA rules as "Toxic Chemicals Subject to Section 313 of the Emergency Planning and Community Right-To-Know Act of 1986." A toxic substance is a chemical or mixture that may present unreasonable risk of injury to health or the environment.

Densities of toxic release sites are highest in and near urban areas such as Little Rock, AR; Fort Smith, AR; Springfield, MO; St. Louis, MO; and areas that have large industries or concentrations of industries. The Spring (Neosho-Illinois River Basin), Lower Arkansas-Maumelle, James, and Illinois watersheds have the highest number and density of toxic release sites in the region. Discharge media for toxic releases include land, underground, air, water, and off-site transfer. Of these media, air releases account for 53 percent of all discharges.

Nonpoint Sources of Water Pollution

Nonpoint sources of water pollution include activities associated with construction, transportation, agriculture, and silviculture. For example, during and after storms, water often washes directly into streams from city streets, parking lots, yards, and construction sites, all of which function as nonpoint sources.

Roads and Highways

Roads, highways, and bridges contribute measurable amounts of pollutants to the Nation's waters. The impervious surface of roads and highways prevents the infiltration of rainfall and causes runoff to increase. Runoff may carry sediments, nutrients, oil, grease, gasoline, metals, salts, and other pollutants generated by vehicular traffic and road maintenance. When the polluted runoff enters a stream, water quality can be degraded. Obviously, roads and highways near streams, lakes, and rivers have the greatest potential to deposit pollutants in water bodies.

Sediment is one of the primary pollutants from gravel and dirt roads. Periodic maintenance of the roadbeds and ditches of these roads exposes soil to erosion (as does neglecting road maintenance). The increase in runoff sediment caused by road construction and maintenance can cause physical changes in the aquatic habitat. Sediment loads can affect channel shape, sinuosity, the ratio of stream length to valley length, and the relative balance between pools and riffles. Increased sediment can also alter the quantity and quality of habitats for fish and invertebrate animals.

Road construction that creates a greater impervious surface area and/or interrupts the subsurface lateral flow of water can increase peak runoff flows. Careful layout and construction of roads can minimize changes in the volume and route of peak flows. When roads occupy a significant proportion of a watershed, total water yield and flow timing will be observably affected.

Places where roads cross streams can be barriers to fish movement and gravel distribution in streams. Low water bridges and culverts in the Highlands affect not only fish migration (by impeding fish movement directly or by creating new, impassable gravel bars) but also gravel distribution in these streams.

Riparian areas are transition areas between the uplands and water bodies. The riparian area filters sediments and absorbs nutrients from upland runoff to varying degrees before it reaches streams. Road construction and maintenance within riparian zones, however, can reduce these filtering and absorption processes.

The Aquatic Team focused on the potential effects of roads in riparian areas (defined here as lands within 100 feet (ft) of streams). Effective management of riparian areas not only produces direct benefits in terms of stream health, it may also lessen the effects of roads and other sources of pollution in the uplands.

All watersheds in the Assessment area have road segments within 100 ft of streams (fig. 25). The Upper Black River, Bull Shoals Lake, Current River, Beaver Reservoir, and Illinois River watersheds have the most road miles within riparian areas. Class 2 roads (State highways and county roads) have the highest number of road miles within riparian areas. Class 3 roads (county and national forest system roads) have the most road miles within riparian areas in national forests.

Agriculture and Silviculture

Agriculture and silviculture are sources of sediment, which is a major nonpoint pollutant of aquatic habitats. Sediment creates turbidity, fills in stream channels and reservoirs, changes aquatic habitat, and carries nutrients into streams. In 1991 and 1992, States attributed 41 percent of their nonpoint source pollution to agriculture and 3 percent to silviculture.

"Potential erosion estimates" are predictions of onsite erosion of agricultural and forested lands. Much of the estimated eroded soil is trapped by vegetation or in depressions in the land. A portion of the estimated eroded soil could enter water bodies and become sediment. Land management practices can influence (positively or negatively) the amount of eroded soil that

Figure 25—Unpaved roads within 100 feet of streams are a major source of sediment entering Highlands' streams.

reaches water bodies. Best management practices (BMP's) and conservation measures can reduce the amount of eroded soil that reaches water bodies.

Potential erosion. Total potential erosion declined in more than half of the watersheds in the Assessment area from 1982 to 1992. The land use category with the highest potential erosion in most Assessment area watersheds was pasture lands. Most watersheds in the Assessment area, however, had no appreciable potential erosion from rangelands. The South Grand watershed had the highest average potential erosion rate in 1992.

Over the years studied, "forest potential erosion" as a percent of total potential erosion in a watershed was 3 percent or less for most of the Assessment area watersheds. Watersheds with the highest "forest potential erosion" as a percent of total potential erosion were in the southern part of the Assessment area. The Fourche La Fave, Ouachita Headwaters, and Lower Little River watersheds had the lowest average potential erosion rates.

Pesticide applications. In addition to sediment, some agricultural and silvicultural activities produce pesticide residues that end up in surface or ground waters. Pesticides are chemicals, primarily synthetic organic compounds, that are used to control unwanted plants, animals, or fungi. These chemicals may have effects other than those intended for their use, including impacts on nontarget organisms, accumulation in soil and water, and degradation of water quality.

Approximately 4.4 million pounds (lb) of active ingredients per year from 130 pesticides were applied on 25 crop types within the Ozark Plateaus Province from 1987 through 1991. The herbicides 2,4-D, atrazine, propanil, metolachlor, alachlor, trifluralin, dicamba, and glyphosate were the eight pesticides used most extensively. The most frequently applied pesticide was 2,4-D, used at an estimated rate of 750,000 lb per year.

Approximately 771,000 lb of active ingredients per year from 128 pesticides were applied on 25 crop types within the Arkansas Valley from 1987 to 1991. The seven pesticides used most extensively were the herbicides 2,4-D, propanil, trifluralin, atrazine, metolachlor, and dicamba and the fungicide sulfur. The most frequently applied pesticide was 2,4-D, used at an estimated rate of 108,000 lb per year.

Approximately 356,000 lb of active ingredients per year from 127 pesticides were applied on 22 crop types within the Ouachita Mountains from 1987 to 1991. In this area, the seven pesticides used most often were the herbicides 2,4-D, dicamba, atrazine, metolachlor, trifluralin, and glyphosate and the fungicide sulfur. The most frequently applied pesticide in the Ouachita Mountains was 2,4-D, with an estimated rate of application of 65,000 lb per year.

Pesticides in surface water. Pesticide data are available for 1,002 samples from 141 surface water sampling sites in the Ozark Plateaus. Many sites were sampled only once (42 sites) or twice (19 sites) during the 1970 through 1990 period of record. About 50 percent of the 1,002 samples were collected in the mid-1970's and early 1980's. Thirty-four of the 50 pesticides were below the detection limit for all the samples collected; 16 pesticides were detected in 132 samples collected from 43 sites. The pesticide detected most often was the insecticide toxaphene, which was detected in 17 of 866 samples from 5 of 112 sites. The concentration of toxaphene in samples where the pesticide was detected ranged from 0.1 to 6.0 mg/L.

Pesticide data are available for 53 samples from 14 sites in the Arkansas Valley. Many sites were sampled only once (four sites) or twice (seven sites) during the 1975 through 1995 period of record.

About 65 percent of the 53 samples were collected in the early and mid-1980's. Three of the nine pesticides were below the detection limit for all the samples collected; six pesticides were detected in three samples collected from three sites. Five pesticides (DDE, DDT, aldrin, dieldrin, and lindane) were detected in 3 of 53 samples from 3 of 14 sites. The maximum concentration for these pesticides was 0.001 mg/L, except for DDT (0.002 mg/L).

Pesticide data are available for 245 samples from 19 sites in the Ouachita Mountains. About 64 percent of the 245 samples were collected in the late 1970's and early 1980's. Sixteen of 23 pesticides were below the detection limit in all the samples collected. Seven pesticides were detected in 13 samples collected from 10 sites. The most commonly detected pesticide was methyl parathion, found in 10 of 234 samples at 10 of 20 sites, with concentrations ranging from 0.001 to 0.002 mg/L.

Pesticides in ground water. Pesticides were detected in 80 of 229 samples of ground water from 73 of 215 sites. Twenty pesticides were detected; a

maximum of five pesticides was detected in any one sample. The most commonly detected pesticides were tebuthiuron, atrazine, prometon, desethylatrazine, and simazine. Maximum concentrations ranged from 0.003 to 1.0 mg/L.

The occurrence and distribution of pesticides are related to land use. Samples with detectable pesticides come from sites having a higher percent of land used for agriculture than samples with no pesticides detected. Pesticides are detected more often in samples from springs than in samples from wells.

For the Ouachita Province, very little data are available from monitoring pesticides in ground water. Commonly applied pesticides in forest land—2,4-D, dichlorprop, hexazinone, and picloram—were not found at any of the eight Ouachita Mountain sites sampled in 1986.

Animal Wastes and Fertilizers. Livestock and poultry wastes are a major source of nutrient loading in parts of the Assessment area. The nutrient composition of animal wastes varies widely with respect to animal species, feed consumption and content, and age. Animal wastes contain three major nutrients (nitrogen, phosphorus, and potassium) essential for plant production and are, therefore, used as a fertilizer for pasture lands. The quantity of nutrients ultimately available for use by plants from livestock and poultry wastes varies substantially from the amount initially excreted. Greatly affecting the nitrogen and phosphorus content of animal wastes are the types of animal housing and waste handling systems used. Also, the longer animal wastes remain in the soil before plant uptake, the more nutrients can be lost through leaching, erosion, and other means.

The Ozark Plateaus had the highest nutrient contributions from animal wastes in 1992—an estimated 7 tons per square mile (tons/mi^2) of nitrogen and 3 tons/mi^2 of phosphorus. At 6 tons/mi^2 of nitrogen and 2 tons/mi^2 of phosphorus available from animal wastes that same year, the Arkansas Valley was not far behind. An estimated 4 tons/mi^2 of nitrogen and 2 tons/mi^2 of phosphorus were available from animal wastes in the Ouachita Mountains in 1992. Beef cattle contributed by far the largest amounts of nitrogen and phosphorus throughout the Highlands; chickens were a distant second.

Fertilizer use increased considerably in the Highlands from 1965 to 1985. In 1985, nitrogen fertilizer application rates for the counties within the Ozark Plateaus ranged as high as 12 tons/mi^2, while phosphorus fertilizer application rates ranged as high as 5 tons/mi^2. In that same year, the range within the Arkansas Valley was from 0 to an estimated 12 tons/mi^2 of nitrogen fertilizer and from 0 to an estimated 1 ton/mi^2 of phosphorus fertilizer, while in the Ouachita Mountains, nitrogen fertilizer application rates ranged from 0 to an estimated 3 tons/mi^2 and phosphorus fertilizer application rates ranged from 0 to an estimated 0.5 tons/mi^2.

Urbanization

Increases in the human population serve as indicators of the many environmental stresses stemming from urbanization, including land clearing, waste treatment, and changes in runoff patterns. Between 1980 and 1990, an 8 percent population increase occurred within the Assessment area watersheds. Twenty-four watersheds experienced population increases of 7 percent or more. Between 1980 and 1990, the rate of urbanization was greater within the Assessment area than nationwide. Two Assessment area watersheds (the Upper Little River in southeastern Oklahoma and the Little Missouri River in southern Arkansas) had a 7 percent decrease in population from 1980 to 1990.

Mineral Extraction

Extractions of some mineral resources have adversely affected aquatic systems within the Assessment area. Effects of mining-related extraction activities primarily come from two sources: (1) increased sediment discharges into streams from present-day operations and (2) runoff waters leaching metals and chemicals into streams from abandoned, unreclaimed mines and ore tailings left by historical operations. (The historical operations took place before modern environmental laws were enacted.)

The primary mining activity in the Assessment area is surface mining of common variety minerals that generally go to the building and road construction industries. In 1996, approximately 698 mining-related operations for hardrock and coal extraction occurred in the Assessment area.

Several abandoned former mine sites continue to contribute chemical and metal leachates and runoff to

streams and other water bodies, increasing acidity in some cases and frequently affecting aquatic resources.

Effects on aquatic resources from present-day mining activities are primarily associated with increased sedimentation of streams caused by instream gravel and sand extraction. Approximately 595 mi of rivers, streams, and lakes are impaired as a result of mining activities within the Assessment area.

Introduced Species

The term "introduced species" refers to a population of organisms of a given species that occurs in a particular locale due to human actions that inadvertently or deliberately moved the species from one place to another. Introduced species such as zebra mussels, common carp, and certain aquatic weeds have become pests and may be regarded as nonpoint sources of environmental degradation.

Arkansas, Missouri, and Oklahoma are making concerted efforts to retard the spread of zebra mussels both through public education and education of individual anglers and boaters. It is likely that zebra mussels eventually will show up in most lakes and reservoirs in the Assessment area as the result of a transient boating public. Zebra mussels are expected to ravage the native mussel fauna as well as disrupt the food chain of any water body they colonize (fig. 26).

Figure 26—Native mussel species such as this Ouachita kidneyshell (collected from the James River, Webster County, MO), are theatened by pollution, habitat alteration, and zebra mussels. (Photo courtesy of M.C. Barnhart, Southwest Missouri State University.)

Water Use

The Ozark-Ouachita Highlands encompass headwaters for 13 major rivers (the Gasconade, Meramec, St. Francis, Neosho, Illinois, White, Black, Kiamichi, Little, Ouachita, and Saline Rivers and portions of the Arkansas and Osage Rivers). These rivers serve instream and offstream water needs for much of the South-Central United States. Streamflow from these rivers eventually empties into the Mississippi River.

In contrast to areas immediately to the east, south, and southwest, the Ozark-Ouachita Highlands have fresh water in abundance. Annual precipitation in the Assessment area averages about 44 in., of which roughly 70 percent evaporates. The rest is available as streamflow, for offstream use, or to recharge ground water reservoirs. Across the entire area in the average year, only 6.7 percent of the 53.7 billion gal/d of water yield is withdrawn for offstream use.

From 1985 to 1995, withdrawals increased in four categories of water use (domestic and public, commercial, thermoelectric, and irrigation) and decreased in three other categories (industrial, mining, and livestock). Increases in withdrawals, especially those at thermoelectric plants and for irrigation, far outpaced decreases, resulting in substantial net increases. Water withdrawals increased 25 percent between 1985 and 1990 and 7 percent between 1990 and 1995. But water supplies vastly exceeded use in most parts of the Assessment area, and projected future use remains a small fraction of supply in most years (fig. 27).

Total withdrawals in the Assessment area in 1995 were 6,622 gal/d (table 2). Of these withdrawals, 1,322 million gal/d (20 percent) were consumed and not returned to a stream; 64 percent of withdrawn water went toward cooling at thermoelectric plants, 20 percent toward crop irrigation. About 78 percent of all withdrawals came from surface water.

Withdrawals vary widely among watersheds but exceed 20 percent of available water in only four. In three of these watersheds (South Grand, Illinois, and Dardanelle Reservoir), withdrawals for thermoelectric plants account for 83 to 97 percent of total withdrawals. In the other (Lower Black) watershed, irrigation accounts for 97 percent of total withdrawals. Thermoelectric plants use water in 15 of the 107 counties in the Assessment area and very large amounts in 8 of those

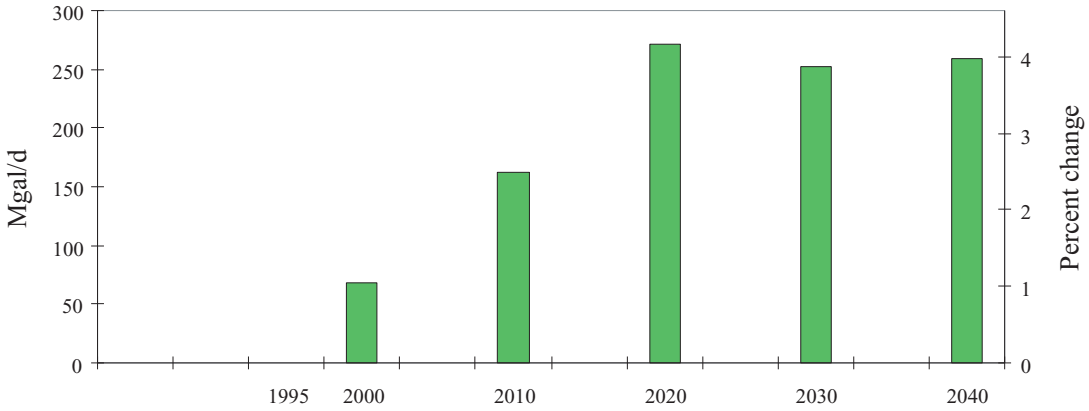


Figure 27—The projected future use of water would remain a small fraction of the supply in most years.

Table 2—Fresh water uses in the Ozark-Ouachita Highlands, 1985–1995

Uses	1985	1990	1995
	- - - - *Million gallons/day* - - - -		
Withdrawal			
Domestic and public	440	464	538
Commercial	97	277	203
Industrial	139	114	136
Thermoelectric	2,947	3,901	4,234
Mining	29	26	11
Livestock	210	149	184
Crop irrigation	986	1,216	1,315
Total	4,847	6,148	6,622
Consumptive use	1,006	1,205	1,322
Hydroelectric water use	141,942	116,793	102,884

counties. Although total annual energy production at thermoelectric plants in the Assessment area is expected to increase significantly, total withdrawals for thermoelectric plants are projected to drop from 4.2 billion gal/d in 1995 to 3.8 billion gal/d in 2040.

Hydroelectric plants operate in 22 Assessment-area counties and use enormous quantities of water—about 103 billion gal/d—but nearly all of this use occurs instream. The three counties using the most water for hydroelectric power generation are Le Flore (OK), Franklin (AR), and Muskogee (OK).

Municipal water supplies provide over 80 percent of the drinking water in the Assessment area. The largest drinking water supplies are located in the Meramec, Arkansas, Kiamichi, and Upper White River Basins, which serve about 1.6 million people. Smaller water supplies in the Assessment area are located in less populated watersheds such as the Upper Black and Upper St. Francis River Basins. Total withdrawals for domestic and public purposes are projected to increase from 538 million gal/d in 1995 to 675 million gal/d in 2040.

Total withdrawals for crop irrigation are projected to increase from 1.3 billion gal/d in 1995 to 2.0 billion gal/d in 2040. Total industrial and commercial withdrawals are projected to decrease from 339 million gal/d in 1995 to 214 million gal/d in 2040. Water withdrawals on the whole are projected to increase until 2020 and remain fairly stable after that, staying within 5 percent of 1995 levels. The increases in withdrawals for domestic and public use and for irrigation should be balanced, for the most part, by decreases in withdrawals for industrial, commercial, and thermoelectric uses.

While the overall picture is one of water abundance, many communities and cities in the Highlands face future shortages and are actively seeking new supplies for domestic and commercial use. For example, Fort Smith seeks to expand its existing water supply lake. Little Rock, which currently has two reservoirs in the Ouachita Mountains, seeks a third source to meet its long-term needs. Many smaller communities (e.g., Benton and Marshall in Arkansas) are actively looking

for new supplies. For a variety of reasons, it is highly likely that communities will look to Federal and State lands for at least some of their future freshwater needs.

Aquatic Animals and Their Habitats

Fishes

The Ozark-Ouachita Highlands are part of a region—the Southern United States plus the Missouri Ozarks—that harbors the richest freshwater fish fauna on the North American continent. The Highlands' streams and rivers alone are home to at least 190 native fish species, representing 51 percent of the native freshwater fishes of the entire Mississippi River Basin, about 24 percent of those of the Continental United States, and 18 percent of all native freshwater fishes of North America.

The Highlands are drained by several major river basins emptying into the Mississippi Alluvial Basin. These can be divided into two major groups: easterly flowing tributaries (primarily the Gasconade, Osage, Meramec, St. Francis, Black, White, and Arkansas Rivers) and southerly flowing tributaries (primarily the Kiamichi, Little, and Ouachita Rivers).

Twenty-three fish families are represented by native species in the Assessment area, with five families containing about 78 percent of the fish fauna of the region; more than half of the fish fauna belongs to two families—the perches (Percidae) and minnows (Cyprinidae). Conservatively, at least 14 percent of the fish fauna is endemic (restricted in geographic extent) to the Assessment area (fig. 28). Endemic species are distributed among five fish families, with highest endemicity among darters and minnows. Endemic fishes are concentrated in 2 ecological sections: the Ozark Highlands (16 endemic fish species) and the Ouachita Mountains (7 endemic fish species).

Two geographic centers of primary levels of fish species richness (89 to 114 species) occur in the Assessment area (fig. 29). One, in the northeastern part of the area, includes portions of Upper St. Francis River, Upper Black River, and Upper White River drainages; in the west, high species richness is concentrated in the drainages of the Neosho-Illinois Rivers and western portions of the Arkansas River. Native fish species density varies across the Assessment area, with the highest densities of fish species associated with units that are generally small and species rich or small and adjacent to species-rich units.

Figure 28—The leopard darter is one of many species that occur only in the Highlands; as a conservative estimate, at least 14 percent of the fish fauna is endemic to the area.

Mussels

Freshwater mussels have been described as an imperiled fauna threatened by habitat destruction, overuse (for commercial or other purposes), disease, predation, introduction of nonnative species, pollution, hybridization, and restricted range. The single most important cause of decline in mussel diversity and abundance has been habitat destruction. Causes of this destruction have ranged from the obvious—dams, dredging, and channelization—to the subtler—siltation and contaminants. Erosion, caused in part by deforestation, poor agricultural practices, and destruction of riparian zones, has led to both increased silt loads and shifting, unstable stream bottoms. While habitat destruction continues, the introduced mollusks such as the Asian clam and zebra mussel appear poised to destroy many remaining native mussel populations.

Seventy-three species of native freshwater mussels representing 37 genera occur within the Assessment area. Eleven species are endemic to the Assessment area; two, the Asian clam and the zebra mussel, are introduced species. Twenty-four freshwater mussel species are widely distributed across the Assessment area, while 16 species are restricted to streams draining

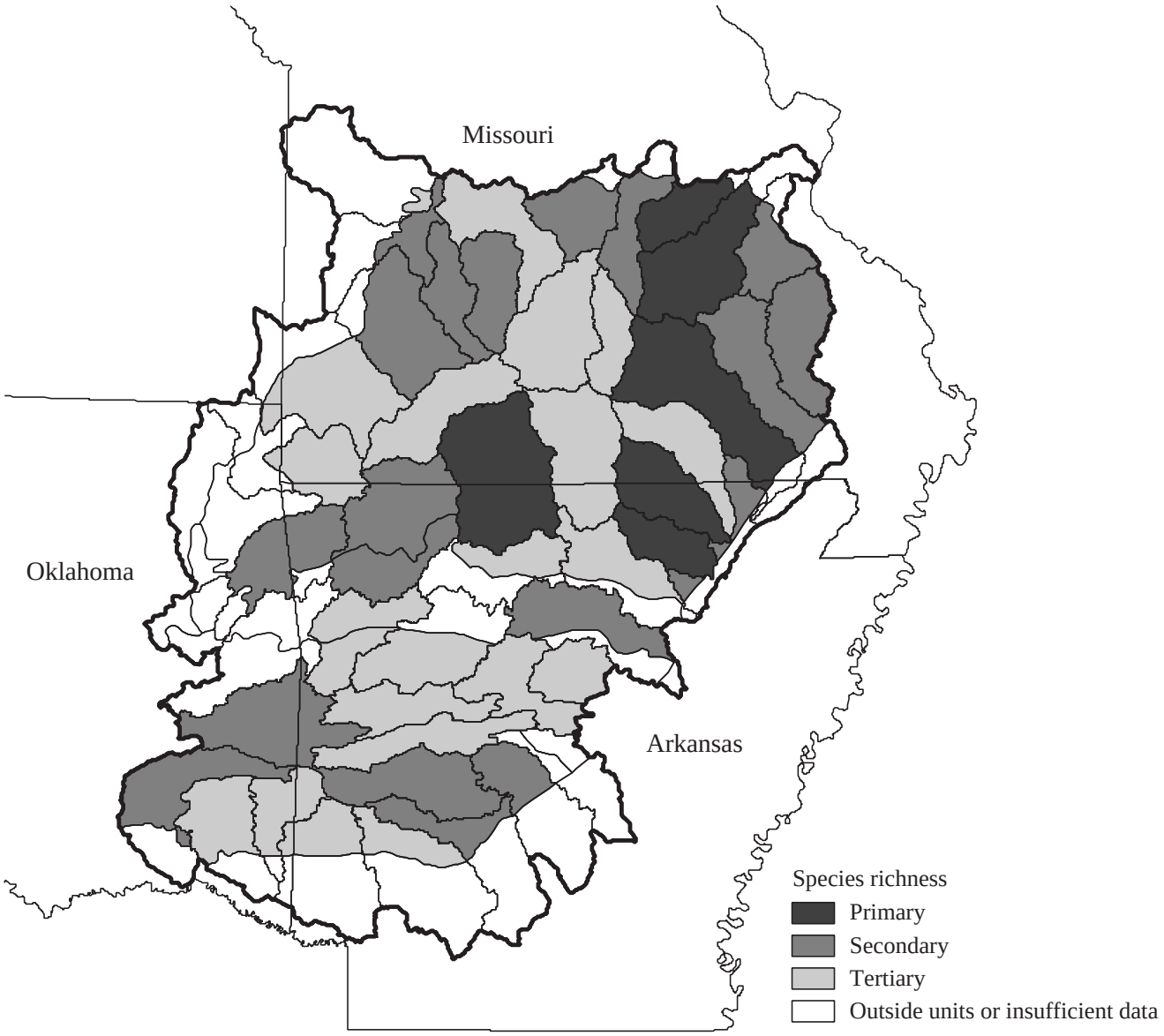


Figure 29—High levels of fish species richness (89 to 114 species) occur in two geographic centers; the northeastern center includes portions of the Upper St. Francis River and Upper Black River, and the western center includes drainages of the Neosho-Illinois River and portions of the Arkansas River. (In this figure, watersheds have been subdivided according to ecological sections; see the *Aquatic Conditions* Report for further information.)

the Ozark Highlands, and 8 species are restricted to streams draining the Ouachita Mountains. North American conservation status rankings for freshwater mussel species in the Assessment area reveal that 40 species are considered currently stable, 18 species are of special concern, 9 are ranked as threatened, and 6 are listed as endangered.

Areas of relatively high species richness and density occur primarily in clusters in the northeastern, central, and southern portions of the Assessment area and appear to be associated with hydrologic units containing both headwater and main stem habitats (fig. 30). The Aquatic Team calculated a relative importance index value to rank hydrologic units in terms of combined mussel species richness, species density, and habitat availability for rare species. The five highest-ranking hydrologic units were the Strawberry River (Upper Black River Basin), the Bourbeuse and Big Rivers (both

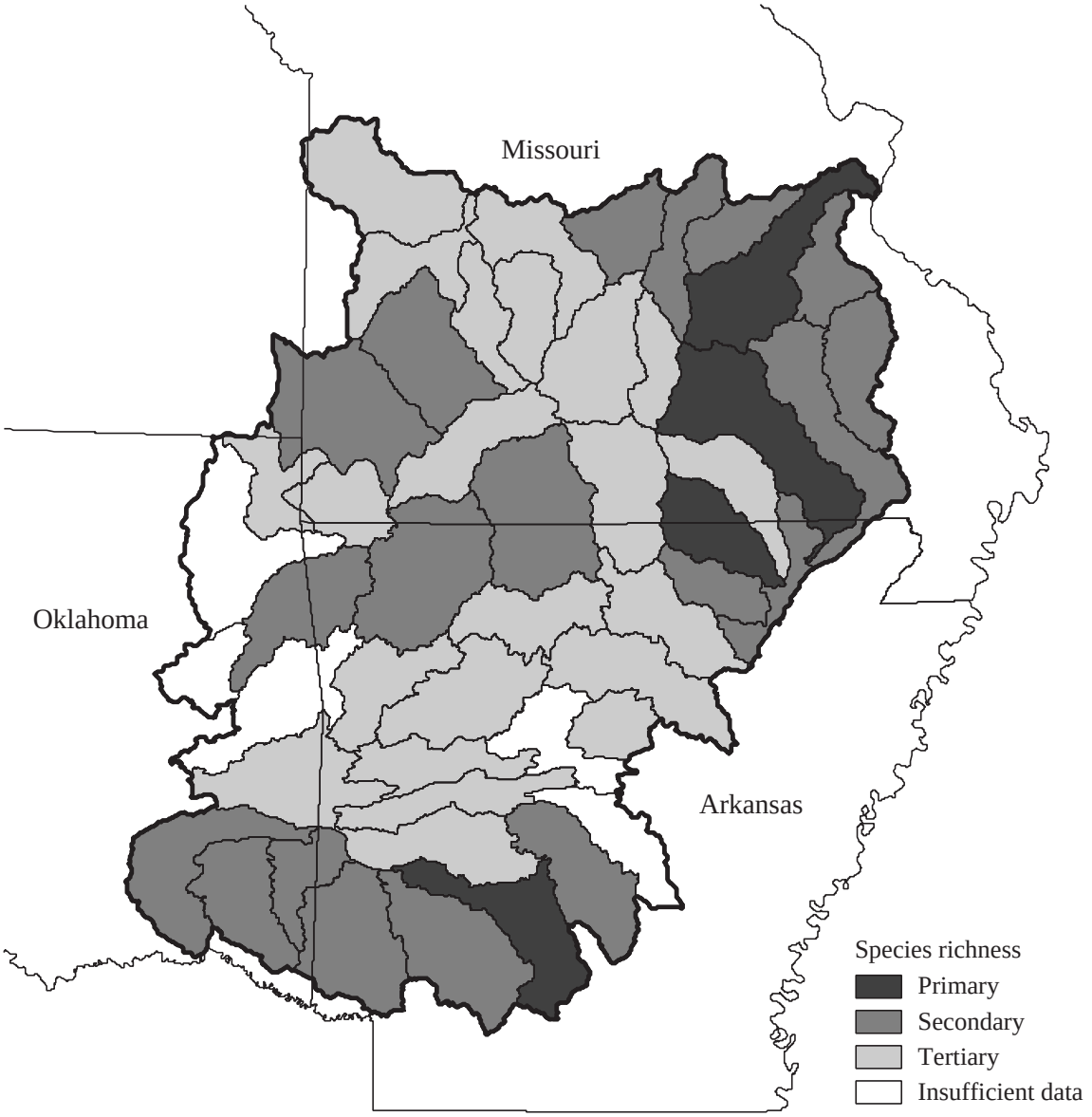


Figure 30—Watersheds having relatively high mussel species richness and density occur primarily in tier-like clusters in the northeastern, central, and southern portions of the Assessment area.

in the Meramec River Basin), the Upper Ouachita River (Ouachita-Saline River Basin), and the Lower Osage River (Osage River Basin).

Crayfishes

Large invertebrates often found in streams, rivers, and lakes, crayfishes are significant components of aquatic ecosystems. They facilitate important ecological processes, sustain recreational and commercial bait fisheries, and are a profitable and popular food. Within the Assessment area, crayfishes often make up a large proportion of the biomass produced in aquatic systems and provide a critical food resource for stream fishes.

Crayfish species representing 6 genera and 1 family (Cambaridae) are present in the Assessment area. The genera *Orconectes* (24 species), *Procambarus* (13 species), and *Cambarus* (9 species) comprise 84 percent of the crayfish fauna, which includes 37 endemic species (61 percent of the region's crayfish

fauna). Most of these endemic species are confined to the Ozark Plateaus and Boston Mountains (at least 22 endemic crayfishes), but endemicity is also relatively high in the Ouachita Mountains (at least 13 endemic crayfishes).

Crayfish species richness averaged 5.9 crayfish species per hydrologic unit, with a range of from 2 to 14 species. However, most hydrologic units showed diverse crayfish faunas, with 29 of 50 units having crayfish richness values greater than 4 species. The southeastern Ouachita Mountains and an area trending southwest to northeast from the western Boston Mountains to the eastern Ozark Plateaus showed primary or secondary levels of crayfish richness (6 to 14 species).

Concentrations of hydrologic units with primary levels of crayfish density occurred along the northeastern edge of the Assessment area (Middle White unit, Upper St. Francis unit, and most units in the Black River and Meramec drainages) and in the southern part of the Assessment area (most units in the Ouachita-Saline drainage and the Lower Little unit of the Kiamichi-Little drainage).

Aquatic Insects

The streams and rivers of the Ozark-Ouachita Highlands harbor a richness of species representing about 15 percent and 17 percent of all stoneflies and caddisflies, respectively, known from North America. Eight families, including 23 stonefly genera and 82 species, and 17 families, including 57 caddisfly genera and 206 species, are known to occur in the Ozark-Ouachita Highlands Assessment area.

The Ouachita Mountains support the greatest richness of stoneflies and caddisflies (195 species) in the Assessment area. Nineteen of the regionally endemic stonefly species occur in the Ouachita Mountains; six of these occur in no other subregion. Three of the 13 endemic caddisfly species found in the Ouachita Mountains are not known elsewhere.

Endangered, Threatened, and Other Aquatic Species of Special Concern

As is true elsewhere, conservation of aquatic biodiversity in the Assessment area is a battle against extinction. The loss of and decline in populations of aquatic species are attributed primarily to alteration of habitats, chemical pollution, overexploitation, and/or the introduction of competitive nonnative organisms. The process of extinction often can be related to landscape- or basin-scale phenomena that decrease habitat area or quality and increase isolation of populations. However, loss of diversity via extinction is not usually observable or cataclysmic. Rather, the process is gradual, with total extinction preceded by local or regional annihilations. Understanding (and ultimately preventing) human-caused imperilment and extinction of aquatic organisms is likely to require far greater focus on landscape-level patterns and processes than traditional approaches to maintaining diverse aquatic communities have used in the past.

A total of 125 aquatic taxa have 1 or more of the following designations: Federal status (14 species), globally imperiled through globally rare (78 taxa), and State critically imperiled (68 taxa). Included are 7 insects; 37 mollusks, 35 of which are freshwater mussels; 23 crustaceans, 15 of which are crayfish; 55 fishes; and 3 herptiles (amphibians or reptiles).

Of the 14 aquatic taxa with Federal status, 6 are mollusks, 2 are crustaceans, and 6 are fishes. Sixty percent of the hydrologic units have at least one federally listed species. Hydrologic units with three or four species with Federal status are located in the southern Ouachita Mountains (Upper Little, Lower Little, and Upper Ouachita units), in the Neosho-Illinois drainage (Lake O' the Cherokees, Illinois, Elk, and Spring units), and in the Sac unit (Osage River drainage). Units with one to two species with Federal status are scattered widely across the Assessment area (fig. 31).

In the Assessment area, about 32, 50, and 26 percent of the native fishes, mussels, and crayfishes, respectively, have Federal status, globally rare ranks, and/or high State ranks. Two concentrations of hydrologic units showed primary levels of endangered, threatened, and other species of special concern (10 to 30 species with Federal status and/or high global or State ranks): (1) along the southern edge of the Assessment area in the Ouachita Mountains and (2) along the northeastern edge of the Assessment area in the Upper Black River and Upper St. Francis drainages.

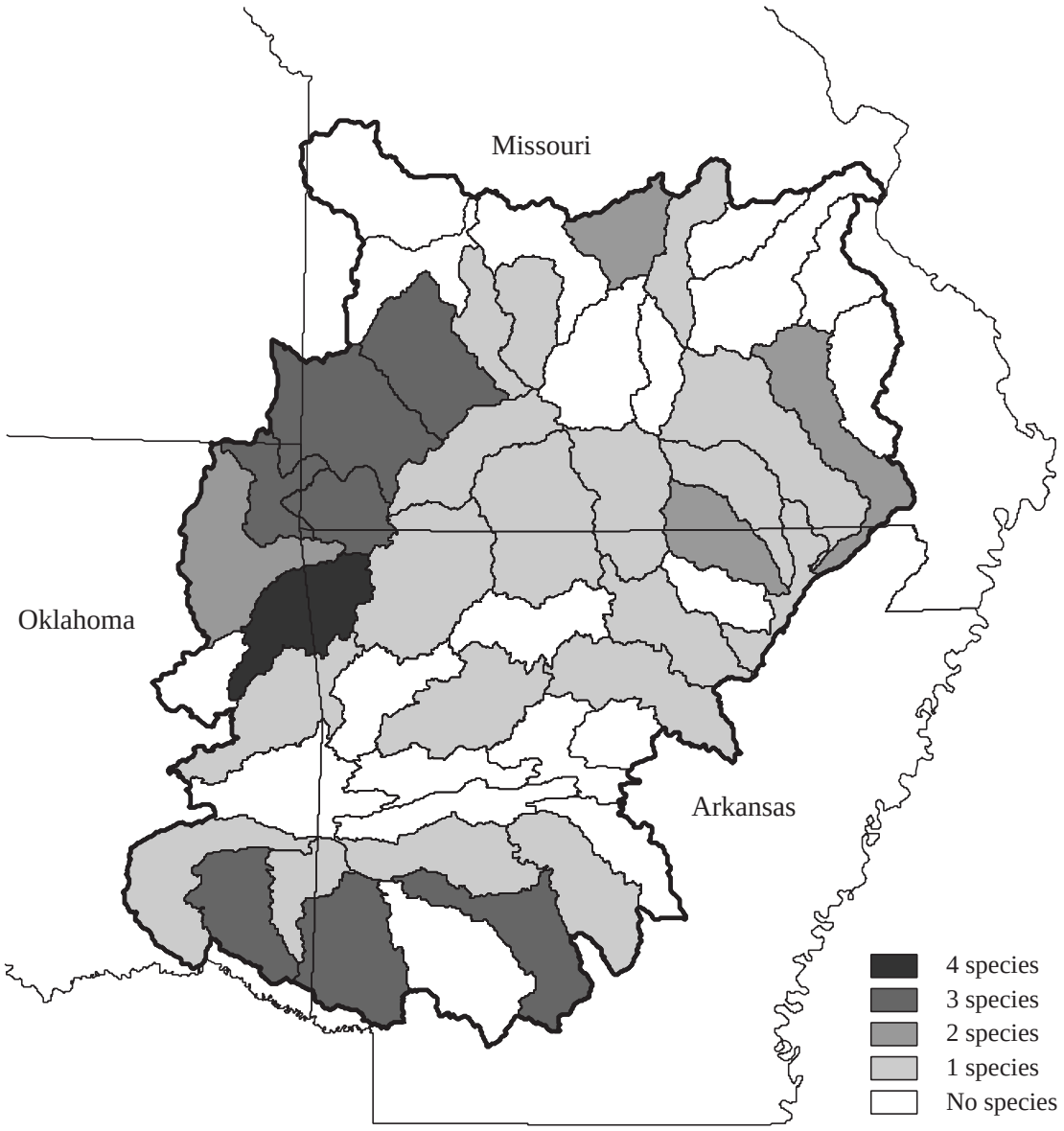


Figure 31—Sixty percent of the watersheds in the Highlands have at least one federally listed threatened or endangered species.

Recreationally and Commercially Important Aquatic Species

In 1996, 35.2 million people 16 years of age and older engaged in recreational fishing in the United States. Within the Assessment area, fishing is one of the more popular outdoor activities. The Assessment area is home to world-class fishing; popular fishing resorts; thriving fishing guide services; major fishing boat and fishing tackle manufacturers, wholesalers, and retailers; and major professional fishing tournaments. These aspects of recreational fishing are highly visible and generate considerable cash flow for the economies of the Assessment area.

The high level of recreational fishing, of course, would not have developed had the fishery resources not been available. While the early inhabitants of the Highlands found plentiful stream and river fishery resources, these environments have been significantly altered by the construction of dams, locks, levees,

reservoirs, lakes, and ponds and by increasing demands on and harvests of fish. Fishery managers respond to the challenge of altered habitats by trying to manage for sustainable yield (through natural fish reproduction) where possible. When necessary, managers supplement and replenish stocks with fish from hatcheries.

Significant efforts have been made—mostly through introductions of nonnative fish species—to manage open-water habitats of large reservoirs within the Assessment area and to utilize adequately cool and cold water habitats within and downstream from these reservoirs. State and Federal fisheries-management agencies protect native stocks of smallmouth bass, walleye, and sauger by foregoing some stocking opportunities that might contaminate these native stocks genetically. Where supplemental stocking is needed in habitats containing protected native species, hatcheries are using spawners of the same genetic stock as the protected native species found in the receiving water bodies.

Commercial fish harvesting within the Assessment area is limited to Arkansas waters, where harvests and the number of commercial fishers are somewhat stable. Commercial mussel harvesting regulations in Arkansas govern whether an area is open, closed, or set aside as a protected area. Oklahoma had only one licensed shell (mussel) buyer in 1997.

Demand for shells is driven by the market for pearl blanks (a round piece of shell inserted in commercial pearl oysters to stimulate pearl formation). Actual harvest levels are lower than harvest limits because of the pearl industry's requirements for a specific color and size.

Aquatic and Riparian Habitats

The presence and abundance of aquatic organisms (e.g., fish and aquatic invertebrates) and features of physical habitats (e.g., stream size) are primary tools to assess the quality of aquatic habitats. To examine the status of aquatic habitats, a series of measurements and samples usually is taken at a specific site or series of sites within a stream or river. Such specific information is unavailable for large portions of the Assessment area.

The Aquatic Team used the number of stream types within hydrologic units to examine the large-scale patterns of diversity of aquatic habitats across the Assessment area. Each "stream type" is a unique combination of three landscape-scale attributes: (1) hydrologic unit, (2) ecological section, and (3) stream size. Each of these attributes may include habitat conditions that influence the number and kinds of aquatic organisms found across the Assessment area. For example, endemic and other native aquatic species are associated with specific drainage systems ("hydrologic units"). Likewise, sections within hydrologic units often have different stream water chemistry and differing conditions arising from the distinctive geological evolution of each section's landscape, riparian zones, and water bodies). Consequently, streams show differences in the makeup of their aquatic communities. Finally, different stream sizes within different ecological sections within a hydrologic unit generally support different numbers of aquatic species.

When combined, these three attributes—hydrologic unit, ecological section, and stream size—provide a description of large-scale differences among running-water habitats within and among hydrologic units. For example, a first-order stream (i.e., smallest headwater) in the Ozark Highlands of the Upper White River hydrologic unit represents a distinctly different stream type than a first-order stream in the West Gulf Coastal Plain section of the Upper Ouachita River hydrologic unit. Likewise, a small stream is expected to differ in physical habitat and faunal composition from a medium-sized river within the same province and hydrologic unit.

Over half of the hydrologic units in the Assessment area have 10 or more stream types per hydrologic unit, and no hydrologic unit has fewer than 5 stream types. Primary levels of stream type diversity (11 to 15 stream types per hydrologic unit) are located mostly in the southern half of the Assessment area; secondary levels (10 stream types per hydrologic unit) are located in hydrologic units along the periphery of the Assessment area.

Native fish species richness is associated significantly and positively with the number of different stream types in hydrologic units. Hydrologic units with primary and secondary levels of stream type diversity and native fish species richness may be considered of particular significance in maintaining present and future aquatic biodiversity within the Ozark-Ouachita Highlands (fig. 32).

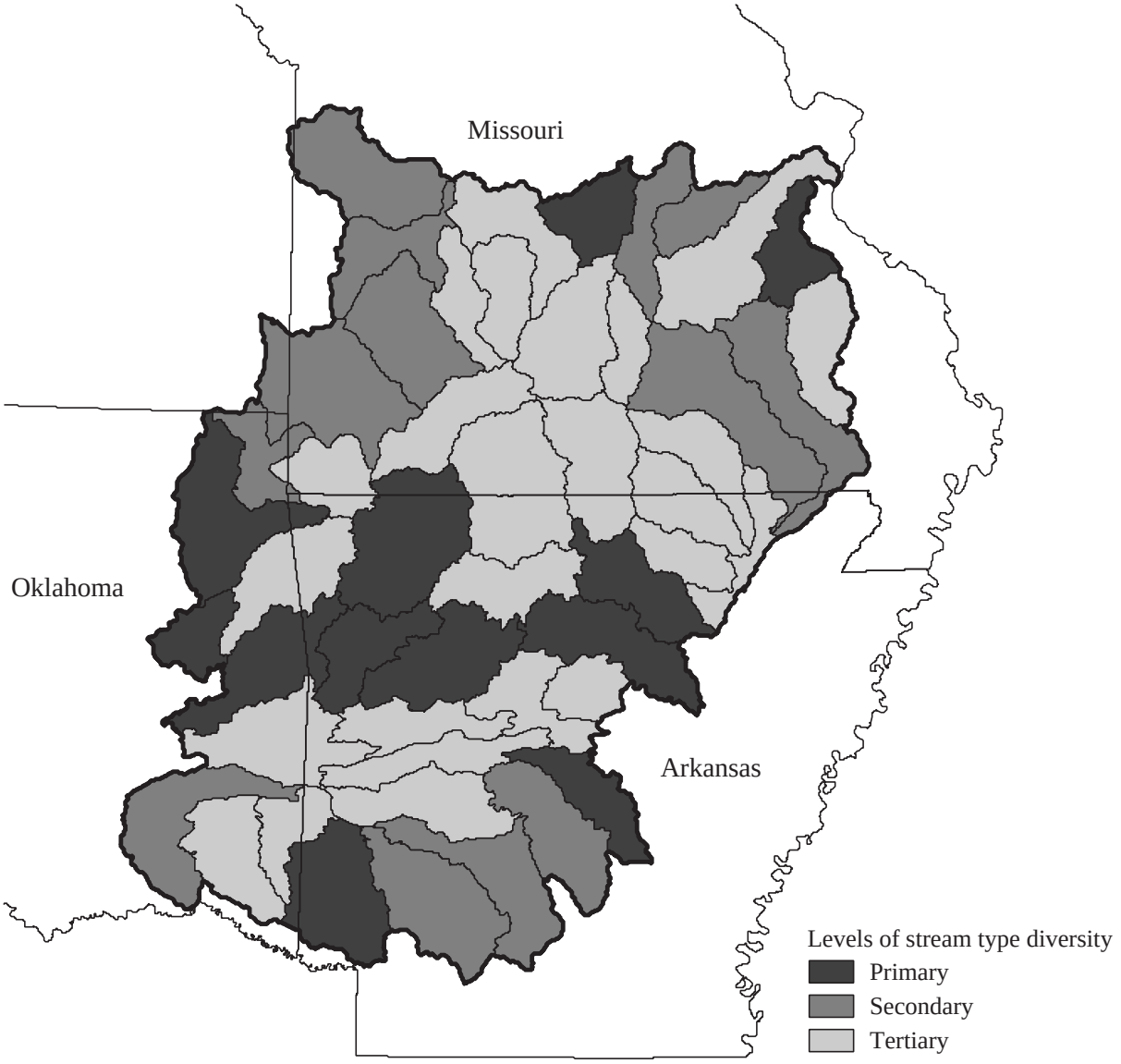


Figure 32—The number of native fish species in a watershed is associated significantly and positively with the number of different stream types in that watershed.

Of the almost 3 million ac of riparian areas identified within the Assessment area, approximately 57 percent of the acres are forested, 37 percent are agricultural, 2 percent are urban, and 4 percent are classified as "other." The Upper Saline watershed has the greatest percentage (87.4 percent) and the South Grand watershed has the lowest percentage (14.9 percent) of forested riparian cover in the study area. National forests generally have highly forested riparian areas (86 to 93 percent).

Since the 1780's, wetland losses in Assessment area States have ranged from 50 to greater than 75 percent. According to the State 305(b) inventory reports of water quality, most of the wetlands in Arkansas, Missouri, and Oklahoma have been converted to agricultural production during historical times.

Most of the State Soil Geographic data base soil-map units that include hydric soils are found along the Grand, Sac, Black, White, Arkansas, Ouachita, and Little Rivers. These areas are potential wetlands because they have saturated soils, one of the essential components of the designation "wetlands."

Camden and Taney Counties, MO, and Pulaski County, AR, had the most Clean Water Act 404 permits issued from 1988 through 1996. If the number of permits issued indicates activity in wetlands and other water bodies, the Osage, Upper White, and Arkansas River Basins had the most activity from 1988 through 1996.

Terrestrial Vegetation and Wildlife Conditions and Trends

The ecosystems of the Highlands are constantly changing. Various kinds of disturbances—including fire, wind, and insect outbreaks—have been integral parts of these ecosystems throughout the history of the area. Humans were present (having arrived some 10,000 years before the present time) as "modern" ecosystems developed, and they likely influenced the structure and function of ecosystems. Beginning in the 1830's, European settlers made dramatic changes to the land by clearing forests and, later, by suppressing fire; settlers also had an impact on animals through hunting and habitat alteration.

Status and Trends of Vegetation

Many people picture the Ozarks and Ouachitas as heavily forested, but grasslands, open woodlands, and savannas are also part of the natural vegetation cover. Some portions of the Highlands (e.g., southwestern Missouri) are primarily nonforest. In the Assessment area as a whole, forests cover about 64 percent of the land.

As measured by Advanced Very High-Resolution Radiometer (AVHRR) data, oak-hickory forest is the most extensive vegetation type in the Assessment area, covering 15 million ac or 36 percent of the area (fig. 33). Oak-pine forest is the second most extensive within the region, covering 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. The abundance of oak in the Ozark-Ouachita Highlands is noteworthy; it is matched or exceeded in only two other Eastern United States ecoregions (the Central Appalachian and Eastern Broadleaf Forest Provinces).

Roughly 95 percent of the forested land in the Assessment area is considered "commercial timberland,"

Figure 33—Oak-hickory forest is the most extensive vegetation type in the Assessment area, covering 15 million acres or 36 percent of the area.

that is, physically capable of producing timber for harvest and not located in a wilderness or other area formally withdrawn from timber production. Although some forest cover data are now available without regard to timber capability, the surveys of commercial timberland that the research branch of the Forest Service has conducted about every 10 years—since the 1940's in Missouri and the 1950's in Arkansas and Oklahoma—represent the best information available about forest trends in the latter half of the 20th century.

Commercial forest land area in the Highlands declined from the 1950's to the 1970's due primarily to conversion of some forest lands to other uses. According to the Forest Inventory and Analysis (FIA) surveys, the largest declines took place in the Arkansas Ozarks and in Oklahoma, where forest cover declined 17.5 percent between the 1950's and 1970's (about 2 million ac and 1.7 million ac, respectively). From the 1940's to the 1980's, Missouri forest cover declined an estimated 14.1 percent (1.44 million ac).

Forested area has been increasing since the 1970's in five of the six survey regions in the Highlands, the sole exception being the Missouri Eastern Ozarks, which continued to show forest cover decreases through the 1980's. Combining all six regions, the net gain in forest area from the 1970's to the 1980's was slightly more than 1.89 million ac. However, the 1990's forest area in the Highlands of Arkansas and Oklahoma is still almost 7 percent less than it was in the 1950's (15.23 million ac versus 16.35 million ac, respectively). Some of the decrease not attributable to conversion was probably due to adjustments made in the estimated natural limit of commercial forest land in the post oak belt of eastern Oklahoma.

The total forest area stocked primarily with small diameter trees (seedlings, saplings, and poletimber) has decreased and the total area of larger diameter trees ("sawtimber") has increased. The total sawtimber volume also increased over time. From the 1950's to the 1990's, sawtimber area in Arkansas and Oklahoma increased from 17 percent to 37 percent of the total commercial forest area; in Missouri, sawtimber area increased from 10 percent to 46 percent.

The area in pine forest cover declined in Arkansas and Oklahoma from more than 3.8 million ac in the 1950's to 2.2 million ac in the 1960's but has since grown steadily except for a minor downturn in the Ouachitas during the 1980's (fig. 34). By the 1990's, pine forest area in Oklahoma and the Arkansas Ozarks had returned to 1950's levels, but in the Arkansas Ouachitas, pine covered only 60 percent of the area occupied in the 1950's. Oak-hickory acres in the Ouachitas in the 1990's were somewhat higher than in the 1950's—the representation of the oak-hickory type rose from about 22 to 30 percent of the total commercial forest acres. Oak-pine acreage doubled in the Ouachitas from the 1950's to 1960's, but part of this increase was due to changes made in FIA measurement standards. It is also likely that an increase in agricultural land uses was responsible for part of the apparent decline in pine.

The largest declines in oak-hickory forest between the 1950's and 1990's occurred in Arkansas and Oklahoma (fig. 35); today these areas have 1.7 million fewer acres of this type than were present in the 1950's—a 17.7 percent decrease. Most of the decline took place in the Arkansas Ozarks and in Oklahoma between the 1960's and 1970's—probably due to conversions to pasture and other agricultural uses. Oak-hickory acreage declined only about 1 percent in Missouri from the 1940's to the 1980's; oak-hickory made up at least 82 percent of the forest cover measured in all three Missouri regions during the 1980's.

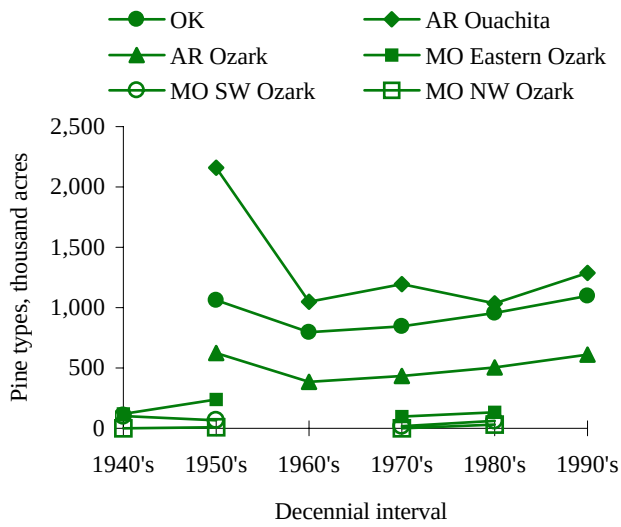


Figure 34—The total area in pine forest cover declined in Arkansas and Oklahoma from more than 3.8 million acres in the 1950's to 2.2 million acres in the 1960's; since then, except for a few minor downturns during the 1980's, there has been steady growth.

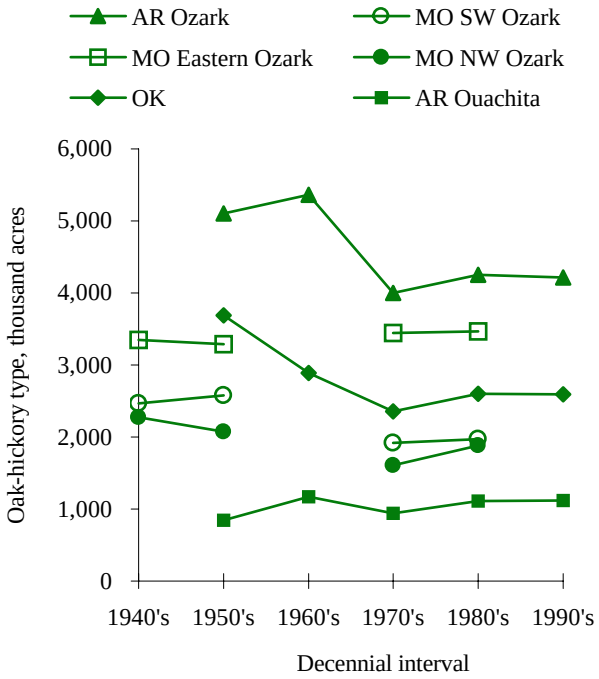


Figure 35—Most declines in oak-hickory forest acreage occurred in the Arkansas Ozarks and Oklahoma.

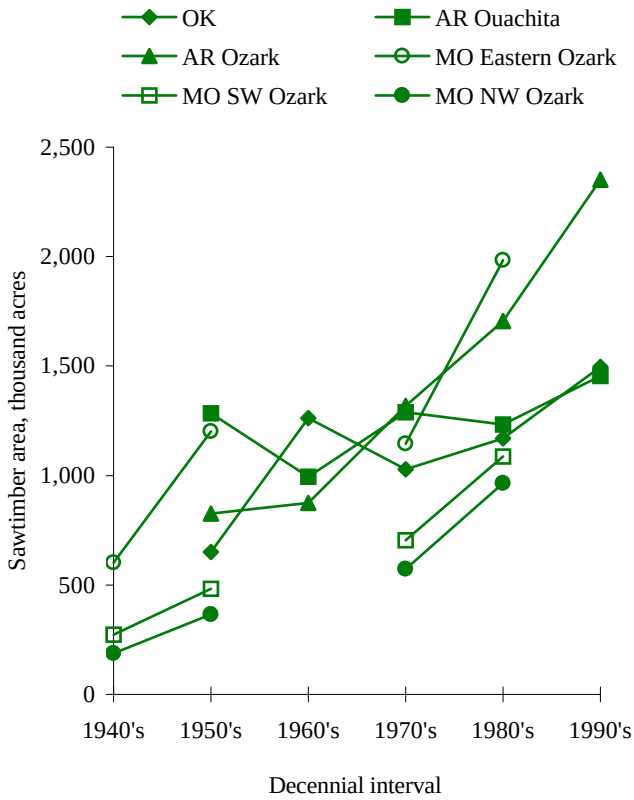


Figure 36—Pine sawtimber (large tree) volume has increased in all regions over time, but the greatest percentage increase was in the Missouri Ozarks.

Hard hardwood growing-stock volumes show upward trends across all FIA survey regions in the Highlands, roughly doubling across the measured four decades, except in the Arkansas Ozarks, where hard hardwood volume nearly trebled. Pine growing-stock volumes also increased dramatically in most survey regions (including the three regions that today have at least 1 billion cubic feet of pine growing-stock volume). The biggest absolute increase was in the Arkansas Ozarks, which saw an increase of eight billion board feet of sawtimber between the 1950's and 1980's.

Pine sawtimber volume has increased in all regions over time, but the greatest percentage increase (400 percent over four decades) was in the Missouri Ozarks (fig. 36). The greatest actual increase (from 6 to 10 billion board feet) was in the Ouachitas. Today, the annual net growth of hardwoods and softwoods is more than double the annual removals. Despite these impressive numbers, forest stands with greater than 1,000 cubic feet per acre of volume occupy only 30 percent of the timberland acreage in the Highlands.

Hardwood forest types occupy 85 percent of the timberland and account for 85 percent of the live trees in the Assessment area. Pine types occupy the remaining 15 percent of timberland area. About 65 percent of the pine types are in shortleaf pine stands of natural origin and about 35 percent are in plantations of either shortleaf or loblolly pine.

Five species—shortleaf pine, white oak, black oak, post oak, and northern red oak—account for 66 percent of the growing stock and 75 percent of the sawtimber in the Assessment area. The proportion of pines that are of growing-stock quality is higher than that of the hardwoods; fully one third of the sawtimber volume on the timberlands of the Assessment area is shortleaf pine. Half of the pine sawtimber volume is on national forests.

About 79 percent of the timberland is privately owned; of that, nonindustrial private forest owners hold 86 percent. Of the 22 percent of the timberland that is publicly owned, 76 percent (about 4 million ac) is in the National Forest System.

Silvicultural Practices and Trends

Between the late 1980's and early 1990's, timber harvesting in the Highlands declined slightly. More recent data suggest that harvests have since increased. Still, the ratio of tree growth to removal is higher for this region than for other areas of the South.

Nonindustrial private owners dominate the timberland ownership pattern in the northern half of the Highlands, and they have significant portions of the land and timber harvests in the southern half. These timberland owners could well play an increasingly important role in local as well as regional and national timber markets.

Upland hardwood forests comprised of relatively shade-intolerant species generally are best suited to even-aged management. Except for one case in Missouri, the few successful examples of uneven-aged management in upland oak forests required aggressive chemical control of competing hardwoods.

Shortleaf pine forests can be managed using a variety of even-aged or uneven-aged methods, but successful regeneration under single-tree selection typically requires chemical and/or mechanical control of competing vegetation. Natural regeneration also depends upon the co-occurrence of good seed crops, suitable seed beds, and sufficient light.

The volume of timber offered for sale on the three national forests in the Highlands declined from about 300 million board feet in 1986 to 225 million in 1997. The low point over the 10-year period—primarily the result of a drop in sales on the Ouachita National Forest in 1991—was 192 million board feet. These three national forests now provide about 10 percent of total national forest "green" timber harvests in the United States.

In 1988, clearcutting accounted for nearly 94 percent (about 27,700 ac) of all acres subject to reproduction cutting on these forests; in 1996, it accounted for less than 3 percent (about 700 ac). This decline in clearcutting represents the single-most significant silvicultural trend on national forests in the Assessment area.

From 1991 through 1996, reproduction cutting on the national forests using the seed-tree method averaged 2,382 ac per year (8.6 percent of the 1988 clearcutting level). During the same period, the area harvested using the shelterwood method averaged 3,157 ac per year (11.4 percent of the 1988 clearcutting level).

The largest increase in the use of a silvicultural method on the national forests was for single-tree selection (fig. 37). This increase was due more to its attribute as the polar opposite of clearcutting than to any innate advantages for either pine or oak-hickory silviculture. Together, the Ozark and Ouachita National Forests applied single-tree selection on an average of 8,916 ac annually from 1991 through 1995.

Herbicide applications for site preparation declined on the national forests from 12,705 ac in 1988 to 2,132 ac in 1997, an 83 percent decrease over the 10-year period. Conversely, acres burned for site preparation on the Ouachita National Forest increased from 536 ac in 1989 to 3,137 ac in 1997. Each year, more acres have been burned than the previous year, which suggests that the limits to using prescribed fire for site preparation have not yet been reached.

The use of prescribed burning as a tool for managing intermediate stands on the national forests increased nearly fourfold in the mid-1990's and exceeded 100,000 ac in 1997 (fig. 38). The Ouachita National

Figure 37—The largest increase in the use of a silvicultural method on national forests was in single-tree selection; clearcutting has declined dramatically on the national forests.

Figure 38—The use of prescribed (controlled) burning as a tool for managing intermediate stands on the national forests increased nearly fourfold in the mid-1990's and exceeded 100,000 acres burned in 1997.

Forest has increased the use of prescribed burning to restore shortleaf pine-bluestem grass communities over extensive areas of the western Ouachitas (fire is the primary ecological tool used in this effort), to sustain wildlife habitat diversity, and to encourage natural regeneration.

Plant and Animal Populations

Species of Special Concern

The long-term viability of at least 333 species of terrestrial plants and animals native to the Highlands is uncertain. Nearly three-fourths of these "viability concern" species live in specialized habitats such as seeps, prairies, glades, and rock outcrops, which can be degraded easily (table 3). Thirty-five (about 10 percent) of these species are imperiled (having 20 or fewer known populations) or critically imperiled (5 or fewer populations).

More than half (53 percent) of the species with viability concerns in the Ozark-Ouachita Highlands are known to occur there only on national forest lands. About one-third of these species are known to occur on private lands only.

Sixteen terrestrial species in the Ozark-Ouachita Highlands are federally listed as threatened or endangered (but two of these—the bald eagle and peregrine falcon—apparently were close to being removed from the list as this report was finalized). The Arkansas Valley section has 10 threatened and endangered species, the Ozark Highlands section has 8, and the Ouachita Mountains and Boston Mountains sections each have 5.

Due to many people's interest in birds, much more information is available about bird species of special concern than any other group. The Terrestrial Team's

Table 3—Species with viability concerns in selected habitat associations of the Ozark-Ouachita Highlands

Habitat association	Animals		Plants		Total	
		Percent		*Percent*		*Percent*
Riparian wetlands, seeps, fens	7	12	70	26	77	23
Mesic forest	9	15	50	18	59	18
Glades, talus slopes, cliffs, rock outcrops	3	5	53	19	56	17
Prairie	15	25	37	14	52	16
Fire-maintained pine/oak woodland	7	12	44	16	51	15
Bottomland hardwood forest	9	15	13	5	22	7
Nonspecific (habitat generalists)	7	12	1	0	8	2
Unknown	3	5	5	2	8	2

analysis of data from the North American Breeding Bird Survey reveals that the populations of more than one-fourth (21 of 90) of the species monitored in the Highlands declined significantly from 1966 to 1996. Six species showed a significant increase during the same period.

The team also determined that nearly one-fourth of the 157 species of birds that probably breed within the Highlands are faced with sufficiently serious problems that they are rated "management concern" species by Partners in Flight. Some of these birds are subjects of international conservation efforts. Neotropical migratory birds (those that winter in the neotropics of Latin and South America and breed in North America) are the focus of one of the largest international conservation efforts ever undertaken for nongame species that are not yet endangered.

In the majority of cases, scientists have insufficient information to conclude which changes—e.g., threats on wintering grounds versus ones in breeding territory—are most influencing populations of the bird species in question. Still, it is notable that forest or shrub/sapling (very young forest) conditions are the primary breeding habitats for 75 percent of these "management concern" species (50 percent require forest and 25 percent require shrub/sapling habitats) (fig. 39).

As an extensively forested region, the Ozark-Ouachita Highlands area is probably of great value to the long-term viability of certain songbirds in North America. Yet only about one-fifth of the species that appear to be declining in the region require forest conditions as their primary breeding habitat. Thirty-eight percent of the songbirds require shrub/sapling habitats, 19 percent need savanna/glade conditions, and 10 percent require grassland habitats. Birds requiring shrub/sapling conditions exhibit some of the steepest population declines in the region.

These trends in bird populations reinforce the need to maintain a mix of younger forests and more open kinds of habitats along with older forests. No single habitat condition is good for all species. Thus, for example, it would be a mistake to assume that the best course for bird conservation in the Highlands is to maximize mature forests or forest cover with a continuous canopy.

Similarly, no single silvicultural practice is inherently good or bad for birds. What any given practice

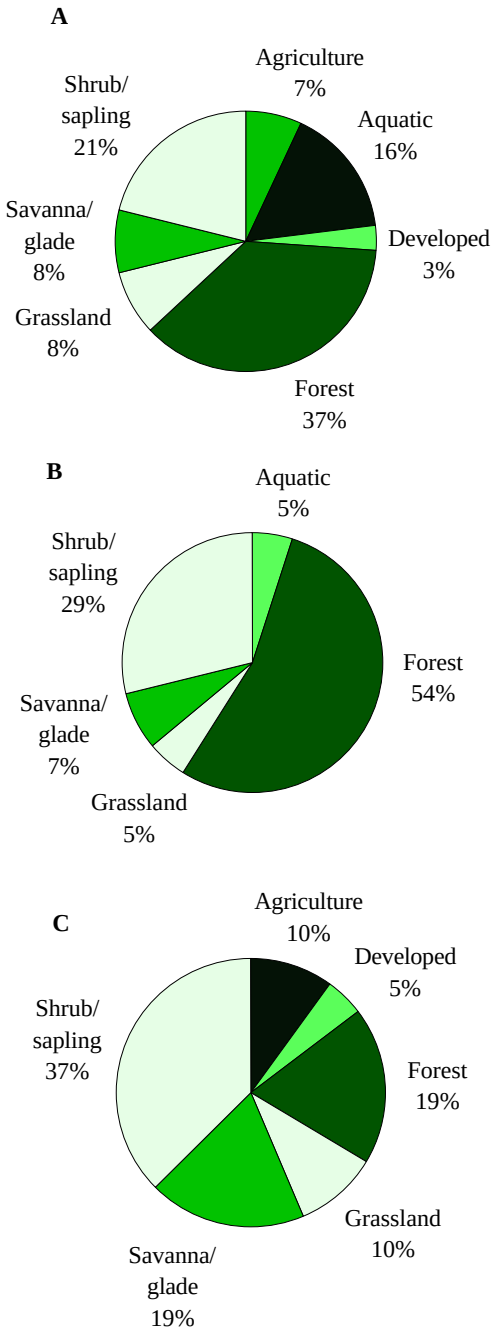


Figure 39—Distribution of (A) primary breeding habitat of all birds, (B) primary habitats of species of management concern (Partners in Flight Landbird Database), and (C) primary habitats of species with significant population declines based on the North American Breeding Bird Survey for the Ozark-Ouachita Plateau region. (Due to rounding, percentages may not sum to 100.)

will do (whether the prescription is even-aged or uneven-aged management or wilderness, i.e., "hands-off" management) is to create habitat for some species that is unsuitable for others. A variety of forest management practices is needed to help meet the habitat needs of the songbirds native to the Highlands. The mix of practices used will heavily influence the abundance of individual species.

Cave Animals

Caves in the Ozark-Ouachita Highlands are habitats for a rich and diverse fauna. The diversity of above-ground habitats, such as forests and springs, contributes to an abundance of cave-dwelling species in the Highlands. These subterranean and surrounding forest habitats are sanctuaries for a number of State and federally listed threatened and endangered species.

There are 409 known caves on the Mark Twain National Forest, of which 306 have been nominated as significant under the Federal Cave Resource Protection Act and 140 have been mapped. These caves are habitat for five federally listed species, including the endangered gray and Indiana bats. Seven of these caves have been gated to control human disturbance.

The endangered gray and Indiana bats and the Ozark big-eared bat use at least 10 caves in the Ozark National Forest. Two of only five known remaining hibernating colonies of Indiana bats in Arkansas occur on the Sylamore Ranger District of this national forest. Blanchard Springs Caverns, also on the Sylamore Ranger District, demonstrates the vulnerability of bat colonies to disturbance. After the Forest Service began constructing trails in the cave in 1963 and opened it to the public for guided tours in 1973, a hibernating colony of 5,000 to 7,000 gray bats dwindled to about 150 in the winter of 1978 to 1979 and dropped to only 33 bats during the winter of 1985 to 1986. Since then, the Forest Service has limited disturbance at the roost site and the bat population has increased dramatically to more than 50,000 in 1995. During the summer of 1996, there were about 34,000 bats present.

Nine species of bats and six species of salamanders use caves and abandoned mines in the Ouachita National Forest. One hibernating cluster of seven Indiana bats occurs in Bear Den Caves during the winter.

Game Animals

Available data for game species in the Highlands show that the numbers of most have increased or remained stable since 1970. White-tailed deer, black bear (fig. 40), eastern wild turkey, and raccoon have higher population densities in the Highlands today than they did in 1970. Bobwhite quail populations are down slightly, eastern cottontail rabbit numbers have remained about the same, and fox and gray squirrel populations have fluctuated, but 1996 numbers for squirrels in Missouri are not much changed from those in 1970.

Extirpated or Extinct Species

Twenty-five species of terrestrial plants and animals that once lived in the Highlands no longer exist there in wild populations. Most of these species were eliminated from the Highlands through habitat loss or overhunting. Mammal and bird species that congregated in large numbers, such as bison and Carolina parakeets, or which people considered destructive predators, such as golden eagles, wolves, and mountain lions, are gone from the landscape (except in captivity in some cases, e.g., bison and mountain lion). Passenger pigeons, once abundant throughout Eastern North America (including the Highlands), were driven to extinction by overhunting.

Figure 40— Available data for game species in the Highlands, including the black bear, show that most populations have increased or remained stable since 1970.

Biological Threats to Forest Resources

The European gypsy moth, a defoliator of hardwood trees, has been found in the Assessment area. The outbreaks have been minor, and eradication has been successful. Scientists expect a general infestation might reach the Assessment area between 2025 and 2050.

Red imported fire ants are invading the Assessment area from the south and are expected to continue a gradual northward expansion. Eradication is probably impossible. An integrated pest management program is the best approach to this problem.

The southern pine beetle is indigenous to the southern part of the Assessment area. Serious outbreaks will continue to occur in the Ouachita Mountains section.

Knapweeds, invasive nonnative plants, have been present for several decades on some roadsides in southern Missouri. These plants pose both health concerns for humans and livestock. Purple loosestrife, a serious pest in wetlands, is present in the Ozark-Ouachita Highlands and may spread. Other invasive, nonnative plants that threaten resources in the Highlands include multiflora rose, kudzu, Japanese honeysuckle, sericea lespedeza, crown vetch, musk thistle, tall fescue, Johnson grass, white and yellow sweet clovers, garlic mustard, teasel, and two species of privet.

Air Quality Conditions and Trends

The major types of air-pollution emissions with the potential to impact the natural resources of the Ozark-Ouachita Highlands are particulate matter, nitrogen oxides, volatile organic compounds, and sulfur dioxide. Emissions of particulate matter are greatest along the northern and western boundaries of the Assessment area, where they are usually generated by fugitive dust sources (e.g., sources of uncontrolled or unducted dust emissions such as dirt roads or agricultural fields). Emissions in the future are expected to remain constant unless wildland fires or prescribed fires increase beyond current levels.

Motor vehicles and electrical utilities are the usual sources of nitrogen oxides nationally. In the Assessment area, however, fuel combustion at industrial sources is the major source of these emissions. Current measures by the Environmental Protection Agency (EPA) are likely to reduce emissions of nitrogen oxides from electrical utilities and possibly from other sources.

Nationally and in the Ozark-Ouachita Highlands, motor vehicles are the main source of volatile organic compounds caused by human activities. Available data were insufficient to enable the Atmospheric Team to project how volatile organic compounds will change in the future.

Fuel combustion from electrical utilities is the greatest source of sulfur dioxide in the Highlands area. The Atmospheric Team expects the amount of emissions to decrease in the future due to the enactment of and full compliance with the Clean Air Act amendments of 1990.

Particulate Matter

Particulate matter (PM_{10}) concentrations show a definite seasonal trend over the Assessment area, with the highest concentrations (averaging 33.05 micrograms per cubic meter [$\mu g/m^3$]) between 1991 and 1995 occurring during the summer months. The average winter concentration was 19.84 $\mu g/m^3$.

There is also spatial distribution of PM_{10} across the Assessment area, with the lowest annual average PM_{10} concentrations occurring in western Arkansas (fig. 41). Rural areas have lower PM_{10} concentrations than urban areas. The Assessment area as a whole is well within the National Ambient Air Quality Standards for PM_{10}.

Implementation of proposed new $PM_{2.5}$ regulations may create a challenge to the prescribed burning programs of farmers and land management agencies such as the Forest Service. Approximately 70 percent of the particulate matter produced by wildland fuels is within the $PM_{2.5}$ size class (particulates with a diameter of 2.5 microns or smaller). Proposed new regulations call for the 24-hour standard to be less than 65 $\mu g/m^3$ and the annual average to be less than 15 $\mu g/m^3$. The 1992 to 1995 annual average concentration of such fine mass particles was estimated at between 9 and 11 $\mu g/m^3$ over the more rural parts of the Assessment area. These concentrations represent 60 to 73 percent of the proposed new standard annual average of 15 $\mu g/m^3$ and 18 to 22 percent of the current annual standard of 50 $\mu g/m^3$. Thus, even with the implementation of the proposed $PM_{2.5}$ standards, the more rural sections of the Assessment area should still be in compliance if current $PM_{2.5}$ concentration averages continue to characterize the region.

According to Forest Service records, most prescribed burning in the Assessment area occurs during March. Average PM_{10} concentrations in the Assessment area during March in 1991 and 1995 ranged from minimums of 10 to 20 $\mu g/m^3$ to maximums of 30 to 40 $\mu g/m^3$, with a mean of 22.7 $\mu g/m^3$. If prescribed fire becomes a more prominent land management tool in the Assessment area during the normal prescribed fire season, total PM_{10} and $PM_{2.5}$ emissions and concentrations in the atmosphere will likely increase during the springtime.

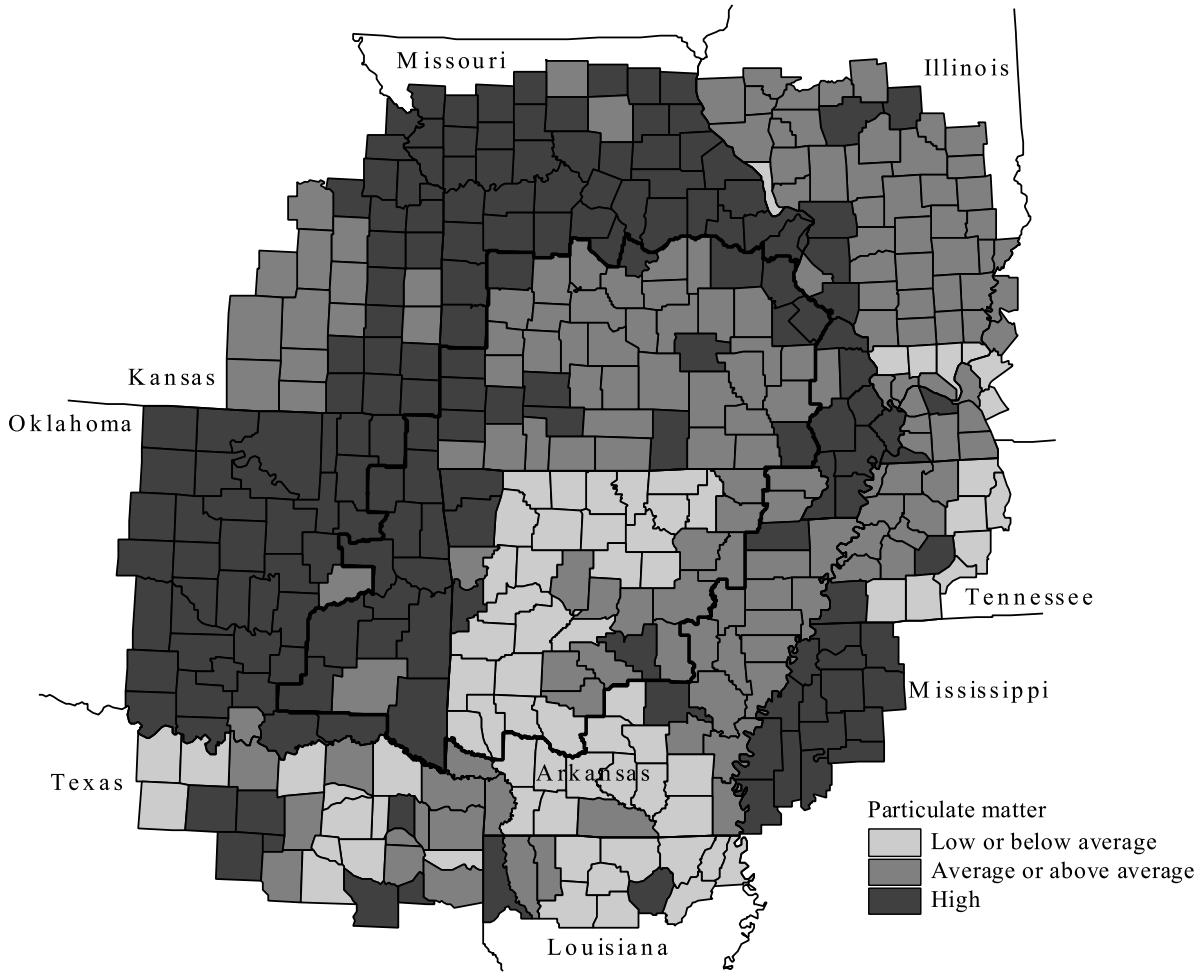


Figure 41—Emissions of particulate matter are greatest along the northern and western boundaries of the Assessment area, where they are usually generated by fugitive (unducted) dust sources. Wildland or prescribed fires also contribute emissions of particulate matter.

Visibility

A definite seasonal pattern exists for visibility. The best visibility occurs during the fall, and the worst visibility occurs during the summer. The Upper Buffalo Wilderness on the Ozark-St. Francis National Forests has the best visibility of the three Class I wilderness areas on national forests within the Assessment area (fig. 42).

Visibility impairment in the form of regional haze exists within the Assessment area. Sulfates are the primary aerosols responsible for such impairment. Compliance with the Clean Air Act amendments of 1990 should reduce sulfates and improve visibility. New $PM_{2.5}$ and ozone regulations, while targeted to improve human health, should have the added benefit of improving visibility through anticipated reductions in atmospheric sulfate concentrations.

Ground-Level Ozone

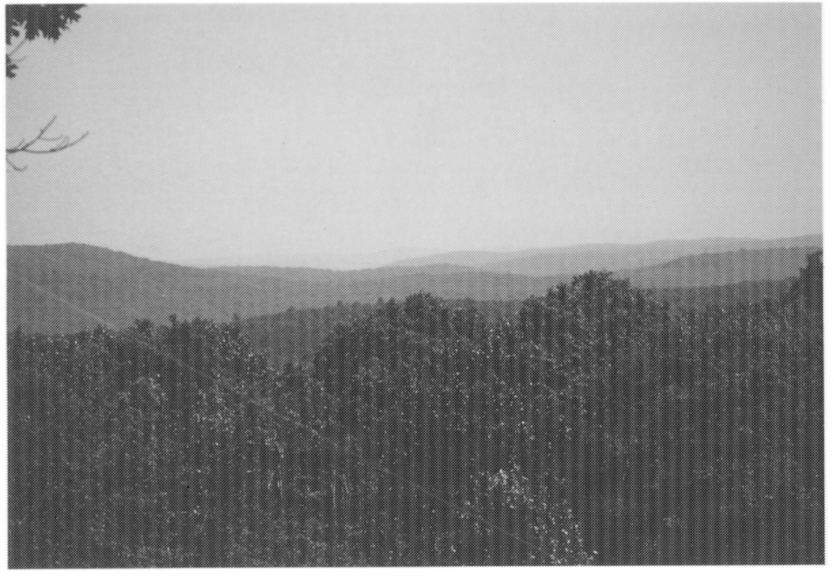
Ozone exposures result from the chemical reaction of nitrogen oxides and volatile organic compounds. The volatile organic compounds are so abundant that it appears nitrogen oxides may be the limiting factor in ozone formation.

Upper Buffalo Wilderness
Visual Range: 93-137 miles

Category: Good
Visibility this good occurs 10-25% of the time.

Upper Buffalo Wilderness
Visual Range: 43-62 miles

Category: Medium
Visibility at this level occurs 40-60% of the time.



Upper Buffalo Wilderness
Visual Range: 25-34 miles

Category: Poor
Visibility this poor occurs 10-25% of the time.

Upper Buffalo Wilderness
Visual Range: < 9 miles

Category: Bad
Visibility this bad occurs less than 1% of the time.

Figure 42—The Upper Buffalo Wilderness on the Ozark-St. Francis National Forests has the best visibility of the three Class I wilderness areas on the Highlands' national forests.

Using available ozone monitoring data, it appears that ground-level ozone had a minimal impact on forest tree growth in the Assessment area between 1990 and 1995. There are few ozone monitors within the Highlands, however, and there could be localized areas where growth losses occurred in trees that are highly sensitive to ozone. Implementation of and compliance with the Clean Air Act Amendments of 1990 should reduce nitrogen oxide emissions nationally by 2 million tons and may reduce ozone exposures further within the Assessment area.

Recently, the EPA notified State and local air pollution control agencies in 22 Eastern States that further reductions in nitrogen oxides are needed for some urban areas to satisfy the national standards for ground-level ozone. Included were Illinois, Kentucky, Missouri, and Tennessee, where the needed reduction of nitrogen oxides is between 35 and 43 percent. Implementation of nitrogen oxide reductions of this magnitude likely will reduce the amount of ground-level ozone in the Assessment area.

Acid Deposition

Acid deposition can pose a threat to forest ecosystems—especially on poorly buffered, higher elevation watersheds. Acid deposition patterns in the Assessment area are affected by emissions of sulfur dioxide and nitrogen oxides and by the patterns of precipitation over the region. Future reductions in the emissions of sulfur dioxide and nitrogen oxides should lead to reduced atmospheric sulfate and nitrate concentrations, thereby reducing the potential for acid deposition episodes. However, future changes in precipitation patterns as a result of changes in regional climate may also influence the amount of acid deposition over the Assessment area.

Atmospheric wet acid loadings in the Assessment area are less than the loadings observed in the Southern Appalachian region and other parts of the Eastern United States. Nitrate and sulfate loadings are expected to decrease in the future in response to regulatory programs.

Most surface waters within the Assessment area do not appear to be adversely impacted by the previous and present rate of acid deposition (fig. 43). The low acid neutralizing capacity headwater areas of the Ouachita Mountains make them most at risk while the limestone areas of the Ozark Plateau are least at risk.

Figure 43—Most surface waters within the Assessment area do not appear to be adversely impacted by the previous and present rate of acid deposition.

Glossary of Terms

abiotic: nonliving.

advance reproduction: the young trees in the understory of a forest stand that will sprout and grow when the overstory trees are cut and removed.

amphipod: crustacean with a thin body and one set of legs for jumping or walking and another set for swimming.

animal unit month (AUM): the unit of measurement for the amount of forage that a cow-calf pair will consume in 1 month.

anthracnose: a disease causing large, irregular dead areas on leaf tissues and often cankers on twigs or stems.

Audubon Society Watchlist: a national list of bird species not yet threatened or endangered but considered of concern because of downward trends in their populations.

autoaccumulating ecosystem: one in which "pools" of suppressed oak seedlings representing at least four cohorts (seedlings of the same age) persist for two decades or more in the understory of a forest. These seedlings germinate and develop without the benefit of natural or human-caused disturbance, but many die before growing into saplings or full-sized trees; in other words, seedling recruitment and depletion typically occur continuously. Once a canopy disturbance (e.g., wind-throw or timber harvest) occurs, the suppressed stems may or may not develop into overstory trees. (See Johnson 1993 for further discussion.)

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

biotic: living or biological.

blow down: tree that has been blown down and lies on the ground.

bract: a modified or reduced leaf-like structure.

cambium: dividing tissue that produces secondary tissues (inner bark and wood).

canker: a visible dead area, usually of limited extent, in the cortex or bark of a plant.

chlorosis: yellowing of plant foliage.

clearcutting: the removal of all the trees on a site for the purpose of utilization and to provide for regeneration of an even-aged stand of trees, usually of a species requiring full sunlight for proper development and growth.

community: an assemblage of organisms interacting in an environment where they form a distinct living system with its own composition, structure, environmental relations, development, and functions.

conservation: the controlled use and systematic protection of natural resources, such as forests and waterways.

d.b.h.: diameter at breast height, usually assumed to be 4.5 feet.

dieback: dying back of twigs and branches from the terminal portions downward.

disturbance factor: any physical or biological factor responsible for change in an ecosystem.

epicormic: a shoot arising spontaneously from a dormant bud on the branch or stem of a woody plant.

extant: currently in existence.

extirpation: the loss of a species from a specific area.

fen: a nonalluvial wetland fed by water seepage and generally characterized by the absence of an overstory canopy.

feral: having escaped from domestication and become wild.

fire-dependent: the characteristic of requiring periodic fire as part of the ecosystem.

fire-tolerant: the characteristic of tolerating periodic fire in the ecosystem, but not requiring fire as part of the ecosystem.

floodplain: low, relatively flat land adjoining inland and/or coastal waters, which is subject to periodic flooding.

forb: an herbaceous plant other than grass.

forest: an assemblage of woody vegetation typically attaining positions in a plant community at the tallest level; attains height and diameter growth of canopy-layer trees within established averages for the species.

forest fragmentation: the breaking up of large, contiguous forested tracts into smaller or less contiguous tracts.

gap-phase dynamics: the process by which overstory trees in a mature forest are gradually replaced by seedlings and saplings in the understory.

glade: an opening in the forest canopy, characterized by herbaceous vegetation.

indicator species: a species of plant or animal whose presence or absence indicates the general health of the community upon which the species is most dependent. Generally, providing for the needs of the indicator species will also meet the needs of most other organisms in the community.

mast: the fruit of flowering trees used by wildlife for food.

mesic: describing sites with a moderate amount of moisture, which support plants that require a moderate amount of moisture.

necrosis: death of host tissue.

neotropical migratory birds: birds which migrate to the neotropics (South and Central America and the Caribbean) during the winter, but breed and nest in North America.

old-growth stand: a stand of trees characterized by a diversity of tree species in several size classes, advanced age, downed logs and snags, large canopy trees, tree fall gaps, undisturbed soils, and other plants and animals that prefer old growth.

pathogen: a parasite that causes disease.

population density: the number of individuals of a species per unit area.

preservation: to protect from damage.

rare: a classification reflecting a species' scarcity in a given area. Rare plants and animals (and eventually communities) are assigned rarity ranks according to The Nature Conservancy's global ranking system.

regeneration cutting: a cutting that provides conditions necessary for the establishment of a new stand of forest trees.

restoration: the process of reintroducing the natural actions (e.g., clearing by wind damage) required by a community in order to restore critical components of the community.

riparian: describing lands associated with bodies of water.

rotation age: the age at which an even-aged stand of trees is scheduled for harvest or regeneration cutting (the actual age depends on management objectives, the tree species involved, and local site conditions).

retention: the process by which areas of special interest are provided a measure of protection while allowing restoration efforts or other natural actions to occur.

savannah: an assemblage of woody vegetation having a scattered distribution with an understory dominated by grasses and forbs maintained by recurring fire; height and diameter growth of canopy-layer trees may be stunted by environmental factors (i.e., weather, shallow soils) or within established averages for the species.

seed tree: an even-aged silvicultural harvest and regeneration system that removes most of the mature stems. A number of trees (generally, 4 to 10 per acre, singly or in groups) are retained to provide seeds to establish the new stand.

seep: a place where groundwater oozes slowly to the surface, often forming a pool; a small spring.

shelterwood cutting: a regeneration cutting method that removes the overstory stand in two or more operations, spaced in time.

silvicultural: of or relating to the culture of trees or forests.

silviculture: the element of forestry that deals with the establishment, development, reproduction, and care of forest trees.

single-tree selection: an uneven-aged silvicultural harvest system that removes selected trees to create canopy gaps. Trees selected for removal may be healthy or diseased, depending on the goals of the landowner.

shelterwood: an even-aged silvicultural harvest and regeneration system that gradually removes most or all trees in a series of partial cuttings, which resemble heavy thinning. Regeneration establishes under the protection of partial canopy cover.

talus: a sloping mass of rocky fragments, usually without vegetation.

tolerance: the ability of a species to develop and attain maturity under the influence of various degrees of shading. Trees said to be shade-tolerant do well in shady environments. Shade-intolerant species require a minimum solar exposure to robustly mature.

vascular: relating to tissues within a tree that carry water, carbohydrates, and minerals up and down the tree.

wildfire: any fire that is not burning for a prescribed management purpose or being managed as a prescribed fire.

woodland: an assemblage of woody vegetation having a scattered distribution more dense than savanna and less than forest; height and diameter growth of canopy-layer trees may be stunted or within established averages for the species.

xeric: describing sites without significant moisture, very dry sites.

Glossary of Abbreviations and Acronyms

ac: acre(s)

BMP's: best management practices

EPA: Environmental Protection Agency

ft: foot or feet

gal: gallon(s)

gal/d: gallon per day

GIS: Geographic Information System.

GLO: General Land Office.

in.: inch

lb: pound(s)

µg/m³: microgram(s) per cubic meter

NIPF: nonindustrial private forest

NPDES: National Pollutant Discharge Elimination System

tons/mi²: tons per square mile

List of Tables and Figures

U.S. Department of Agriculture, Forest Service. 1999. Ozark-Ouachita Highlands Assessment: summary report. Report 1 of 5. Gen. Tech. Rep. SRS-31. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 56 p.

This publication summarizes four other reports prepared as part of the Ozark-Ouachita Highlands Assessment. The summary report addresses social and economic conditions and trends, aquatic conditions, air quality, and terrestrial vegetation and wildlife of the Highlands in Arkansas, Oklahoma, and Missouri.

Keywords: Air quality, aquatic conditions, national forests, social-economic conditions, terrestrial vegetation and wildlife.

The Forest Service, U.S. Department of Agriculture, provides leadership in the management, protection, and use of the Nation's forests and rangelands. The Agency takes an ecological approach to the implementation of multiple-use management, providing sustained yields of renewable resources such as water, forage, wildlife, wood, and recreation. The Forest Service has embraced ecosystem management as its operating philosophy and is committed to the preservation of wilderness, biodiversity, and landscape beauty as well as the protection of the basic resources of soil, water, and air quality.

The Forest Service is responsible for the 191.8-million-acre National Forest System, with its 155 national forests and 20 grasslands in 44 States, Puerto Rico, and the Virgin Islands. In addition, the Agency works with State land management organizations to help private landowners apply good natural resource management practices on their lands. The International Program of the Forest Service enables the Agency to share its technical expertise and managerial skills with other nations. The Research and Development Program of the Forest Service conducts extensive research to enhance and protect productivity on all of America's forests and rangelands, with special attention to long-term natural resource issues of national and international scope.

This report summarizes the findings of four technical reports—*Air Quality*, *Aquatic Conditions*, *Social and Economic Conditions*, and *Terrestrial Vegetation and Wildlife*—that document the results of the Ozark-Ouachita Highlands Assessment.