Chapter 2: Prehistoric and Historic Ecological Changes

Question 2.1: What were the historic and prehistoric ecological conditions in the Ozark-Ouachita Highlands?

Change occurs constantly in the Ozark-Ouachita Highlands, as it does in all ecosystems. Since the last glacial period, 20,000 years ago, when continental glaciers approached the Highlands, climate, natural communities, and species have been in constant flux. Even now, natural occurrences such as droughts, floods, and tornadoes cause dramatic changes in the landscape and in relationships among species. Such events are not only natural, they are vital to the way ecosystems function.

Human activities also cause changes. Some activities may only alter patterns of "natural change" including, for example, prevention and suppression of fire, some forms of timber management, and controlled hunting and fishing. Such activities may affect biodiversity—the variety of species interacting within an ecosystem. They may also alter the structure or dynamic processes of an ecosystem. Where natural processes are significantly altered, ecosystems can be stressed and vulnerable to further damage.

Some activities, such as conversion of forest land for agriculture, mineral extraction, plantation-based timber production, or urban development, can cause large-scale changes that reduce and/or fragment wildlife habitat for some species, which, if sufficiently severe, can mean their extinction. Such changes may completely supplant long-standing ecological relationships and cause revolutionary, rather than evolutionary effects. Contamination of groundwater, introduction of nonnative species, and overhunting of game are other human actions that fundamentally change ecosystems.

The interaction of different change factors, or what ecologists often call "disturbance factors," has consequences, as well. For example, floods in heavily managed or developed watersheds may be more destructive than in less altered watersheds. Even activities outside the local ecosystem may cause effects within it, such as altered climate or acid rain.

An understanding of earlier conditions helps research scientists and managers evaluate the ecological potentials of various landscapes or sites and identify opportunities for appropriate management actions. If shortleaf pine production or pine woodland restoration is an objective, it is useful to know the prehistoric range of this species and what kept it from dominating in other areas. In developing landscape management plans, it is important to know what percentage of the landscape was typically in a regenerating condition at any point in time, how regeneration took place, how much was woodland or prairie, how much was "old growth," and the dynamic equilibrium that existed among these various states which, together, sustained the biota.

Knowledge of historic vegetation and patterns of change aids in the identification of current old-growth areas and selection of appropriate management techniques for them. It also provides a useful baseline for evaluating the effects of management on natural systems. Differences between structure and function of existing and historic forests and between effects of management techniques and natural disturbance processes may be estimated using information about past vegetation.

Key Findings

1. American Indians influenced vegetation patterns through their use of fire.
2. European settlers began making dramatic changes to the land commencing in the 1830's through land clearing and the suppression of fire; settlers also had an impact on animals by reducing certain habitats and by overhunting.
3. Because people have been a constant influence on plant communities and ecosystems of the Highlands for thousands of years, ideas of "natural" (i.e., not human-influenced) conditions need to be reviewed carefully, even challenged.

Data Sources

Clues to the composition and structure of the Highlands in history and prehistory are provided by historical descriptions, evidence in old-growth forests and natural areas, tree rings and pollen evidence, and field notes of General Land Office (GLO) surveyors of the 19th century.

Travel accounts and other historic descriptions are important sources of information on past conditions. Dunbar and Hunter led an expedition, commissioned by Thomas Jefferson, to the hot springs of the Ouachita Mountains in 1804 and 1805 (Rowland 1930). Edwin James (1823), botanist for the Stephen Long expedition to the Rocky Mountains in 1819–1820, described the Ouachita Mountains and Arkansas Valley. Thomas Nuttall (1821) provided a very detailed description of the Arkansas Valley and the western portions of the Ouachita Mountains. Henry Rowe Schoolcraft's (1821) account of his 1818 and 1819 travels through the Ozarks is the most widely cited description of that region. Gerstäcker (1881) provided descriptions of the Ouachitas and Ozarks of the late 1830's, at approximately the time of the GLO surveys. Ladd (1991) provided a comprehensive survey of historic references to vegetation and fire in Missouri, including the Missouri Ozarks.

GLO surveys of parts of the Assessment area are important sources. Foti and Glenn (1991) used notes from the original 1830's Federal land survey to analyze vegetation at three locations in the Assessment area: a site east of Waldron, AR, at the southern edge of the Arkansas Valley Mountains subsection, known as Bee Mountain; a site south of Waldron, in the Fourche Mountains, that currently supports a red-cockaded woodpecker population; and a north-to-south transect crossing the Fourche Mountains, Western Ouachita Mountains, and Athens Piedmont Plateau subsections near the Arkansas-Oklahoma State line, covering more of the range of sites of the region.

In addition, Kreiter (1995) analyzed historic vegetation of the McCurtain County Wilderness Area, an old-growth forest that has not been subject to timber harvest in the Central Ouachita Mountains subsection of eastern Oklahoma. He used GLO Survey notes from 1896 and compared them to a new survey of vegetation at the same points. Lockhart and others (1995) and Harmon and others (1996) used GLO and modern data to characterize the vegetation of the Lee Creek Unit of the Ozark-St. Francis National Forests. Nelson (1997) analyzed witness trees and narrative notes along the 5th Principal Meridian through Arkansas and Missouri, comparing statistics of the Ozark Plateau (principally in Missouri), the Mississippi Alluvial Plain (in Arkansas), and the Dissected Till Plain (in Missouri). Schroeder (1982) used GLO notes and maps to map the presettlement distribution of prairies in Missouri. Finally, Fletcher and McDermott (1957) used historic sources to map the presettlement range of shortleaf pine in the Ozark Highlands.

All historic sources must be used with caution, since many writers are not scientists and their descriptions are not often subject to independent verification. However, all of the travel writers listed above except Gerstäcker were scientists. In several instances their travel routes have been followed and key findings verified. Of these, Schoolcraft may be the most controversial, since he was cited by both sides in a rancorous dispute over vegetation of the Ozarks (Beilman and Brenner 1951, Steyermark 1959), where Beilman and Brenner argued for rapid change in vegetation in the Highlands whereas Steyermark argued for stability. However, when read as a whole, the Terrestrial Team considers his account a reliable historic source. The GLO surveys have been widely used and widely criticized, since they represent the only comprehensive, quantitative data on vegetation of the early to mid-1800's, and yet were not collected for scientific purposes by scientists. Their validity should be assessed on a township-by-township basis before placing reliance on them.

Grazing data reflects the Forest Service's Grazing Statistical Summary and the Natural Resource Conservation Service's National Resource Inventory, as well as published reports. Data concerning the volume of grazing on national forest lands are reported in Animal Unit Months while, for other lands, the data consist of acreage devoted to grazing.

Patterns and Trends

Major Changes in Vegetation

As recently as 20,000 years ago, continental glaciers advanced near the Highlands (to central Illinois). Although glaciers have never encroached on the Highlands proper, climatic effects during glacial periods totally changed the region's ecosystems. Cool, damp, glacial-front climate led to dominance of boreal spruce, fir, and jack pine forests throughout the region for about 6,000 years after the latest glacial maximum.

Oak, ash, elm, and other deciduous trees became dominant around 14,000 years ago and prairies became established in eastern Oklahoma about 2,000 years later (Delcourt and Delcourt 1991). The oak-hickory woodlands and forests characteristic of the region today may have persisted in sheltered coves throughout the glacial interval and subsequently increased in abundance or retreated elsewhere and returned. Presence of numerous endemic species in the Highlands flora and fauna argues for at least some continuity of the biota even during these periods of dramatic change (Hawker n.d.).

Some 10,000 years ago, at the same time that humans arrived in the Highlands, the climate became warmer and drier for a period of several thousand years, allowing expansion of prairies, oak savannas, and oak-hickory forests or woodlands (Delcourt and Delcourt 1991). As prairies and savannas spread over the region, mesic (moist soil) oak-hickory forest communities again retreated to sheltered coves and moister sites or migrated away from the region.

Only in the past several thousand years has climate in the region changed enough to support an upland hardwood forest, and only during this latest interval (the past 4,000 years) has pine forest become dominant in parts of the region (Delcourt and Delcourt 1991). Over this interval, a prairie-dominated landscape changed to a forest-dominated landscape with inclusions of prairie (Albert and Wyckoff 1981). Even during the last 550 years there have been at least three dry intervals severe enough to reduce pine dominance in the Ouachitas (Albert and Wyckoff 1981).

American Indians played a part in shaping these changes in vegetation. At least in portions of the Highlands, Indian populations may have peaked in the 16th century at the time of De Soto's incursion, after which smallpox and other factors reduced their numbers. Prior to that time, productive areas were settled and agriculture was practiced. Even small populations could have had major effects on the landscape through their use of fire.

European settlers began making major changes in the region's landscapes by the 1830's, both through clearing of land and changes in natural processes such as fire regimes. This trend reached a peak from the late 18th to early 19th centuries, when railroads carried away much of the standing timber and brought farmers and even tourists, causing massive and irreversible changes in the landscapes of the Highlands. Forests became shrubby second growth or cotton fields that were abandoned and only after decades became forests again. Fires often increased in intensity and frequency as the slash dried and burned and then decreased as areas became more settled. Open woodlands, savannas, and prairies became forests or shrubby thickets.

Changes in Wildlife and Plant Populations

Expanding settlements caused long-term changes in the populations of game species. Deer populations in the Highlands have fluctuated greatly, from abundance in the early 1800's to near extirpation in the early 1900's. Deer recovery began in the 1930's (but only reached substantial proportions decades later) with closed seasons, strict law enforcement, and restocking (Halls 1984). Refuges on national forest lands also supported the recovery of deer populations in the Assessment area.

Early reports of eastern wild turkeys in the Highlands suggest densities of 5 to 10 birds per square mile. By the early 1900's, the bird's population was drastically lower over most of the region (Lewis 1992), due to overharvesting. By the 1940's, only isolated populations remained. Habitat for wild turkeys began to improve on public lands after initiation of fire and timber management programs and the closing of "open range"—areas where anyone's stock was allowed to graze.

The black bear was a common resident of the Highlands during the 1800's but was rare by 1850 because of overhunting (McKinley 1962). During the period from 1890 to 1920, much of the Highlands' forest was systematically logged and cleared, eliminating the black bear population from the region (Clark 1988). The Arkansas Game and Fish Commission successfully re-established black bears in the Ozark-Ouachita Highlands of Arkansas between 1959 and 1967 (Rodgers 1973, Pharris 1981). Since then, populations have grown and expanded, increasing the sightings of bears in adjacent areas of Oklahoma and Missouri.

At times, the Highlands have had large populations of gray and fox squirrels. During the 19th century, individual hunters could easily kill more than 100 squirrels a day. The "big squirrel kills" were a thing of the past by 1934, due to habitat reductions.

Clearing of forests supported expanding populations of bobwhite quail, with the bird's numbers peaking immediately after areas were cleared for agriculture, then abandoned. But populations declined by the 1920's as land use became more intensive. Populations stabilized by the 1940's, albeit at lower levels than historically, to provide consistent bird crops, but fluctuated again in the 1960's (Stanford 1970).

Similarly, clearing of forests led to expanding populations of eastern cottontail rabbits, which inhabit prairies, glades, and open woods with grassy understories. The rabbit reached a population peak during the pioneer agricultural period (Anderson 1940). "Ozark" rabbits were said to command a premium price because of their size and grading. During the early 1900's, Springfield, MO, was the largest reshipping center in the region, with an annual output of 2 million rabbits (Leopold 1931).

Raccoon populations have increased in the past 50 years. A population explosion began with the 1943 breeding season, and the species has remained at high levels since (Sanderson 1987). It is estimated today there are 15 to 20 times as many raccoons in North America as there were during the 1930's. (See Chapter 5 for recent trends for game species.)

At least 25 species of terrestrial plants, vertebrates, and invertebrates existing historically in the Ozark-Ouachita Highlands are extirpated. (An extirpated species, as used here, is one eliminated as a wild species from all or part of its historical range.) Mammal and bird species congregating in large numbers, including bison and Carolina parakeets, or which people considered destructive predators, such as golden eagles and mountain lions, are gone from the Highlands landscape (although the occasional reintroduced bison can be spotted in a few pastures).

Major factors contributing to the extirpation of these species in the Ozark-Ouachita Highlands included loss of habitat and overhunting. Plant species at the edges of their ranges and parts of rare communities also have been vulnerable to loss of habitat and to extirpation (see "Rare Communities" in Chapter 3). The following species have been extirpated in the Assessment area (and, in some cases, throughout their range):

Species	**Major factor in extirpation**
American swallow-tailed kite	Loss of habitat
Bison	Overhunting
Black-fruit mountain-ricegrass	Loss of habitat
Black lordithon rove beetle	Unknown
Carolina parakeet	Overhunting
Clustered poppy-mallow	Loss of habitat
Creamflower tick-trefoil	Loss of habitat
Ditch-grass	Loss of habitat
Eastern prairie white-fringed orchid	Loss of habitat
Eaton's lipfern	Loss of habitat
Field sedge	Loss of habitat
Golden eagle	Predator control
Horsetail spikerush	Loss of habitat
Ivory billed woodpecker	Loss of habitat
Marsh blazing star	Loss of habitat
Missouri blackberry	Loss of habitat
Mountain lion	Predator control
Northern raven	Predator control
Osprey	Predator control
Passenger pigeon	Overhunting
Peregrine falcon	Predator control
Red wolf	Predator control
Torrey's bulrush	Loss of habitat
Yellowleaf tinker's-weed	Loss of habitat

Historic Changes by Ecological Section

Historic accounts and GLO data reveal more details about the historic period in various ecological sections and subsections of the Highlands. (Ecological units are displayed in fig. 1.1.)

Ozark Highlands

Schoolcraft's account of the White River country in 1818–1819 indicates rich biodiversity and varied ecological communities in the Ozark Highlands. His daily log, with distances traveled and vegetation encountered each day, is an invaluable record of the area he crossed (all page references for this section are to Rafferty 1996).

He described the Meramec River Hills subsection as “hills crowned with oaks” (p. 21), then “yellow pine [and] the soil being sterile, and vegetation scanty” (p. 22) with rich forest lands along the Fourche a Courtois (p. 23) followed by “a succession of sterile ridges, thinly covered with oaks” (p. 24). The Osage Fork of the Meramec had “extensive prairies all along its banks” (p. 24). He also found “barren prairie country” (p. 26). The Current River Hills subsection had “lofty forests of pine” and along the Current River the “soil [was] rich and covered with a heavy growth of trees” (p. 26), as well as ridges covered “thinly with yellow pine, and shrubby oaks . . . .” (p. 35).

He described the Central Plateau subsection as “highland prairie, with little timber, or underbrush and covered with grass. It is a level woodless barren covered with wild grass and resembling the natural meadows or prairies of the western country in appearance, but lacks their fertility, their wood, and their remarkable equality of surface” (p. 35–36).

In the White River Hills subsection, on the headwaters of the North Fork of White River, travel was initially over “rich bottom lands, covered with elm, beech, oak, maple, sycamore and ash” (p. 41). Turning west from the stream “to completely disengage ourselves from the pine-forest . . . we found ourselves on an open barren, with very little timber . . . we passed over a sterile soil, destitute of wood” (p. 44). Following a tributary to the west, Schoolcraft found the going rough, owing to thickets along the stream. Attempting to cross canebrakes and a swamp, his horse became mired: “sunk in soft black mud so deep that the upper part of his back and head were only visible” (p. 58). He and his companion eventually extricated the horse from what must have been a deep muck fen, an unusual community type in the Ozarks.

In the White River Hills subsection Schoolcraft found cane thickets and forests of oak, ash, maple, walnut, mulberry, sycamore, hickory, and elm on alluvial soils. He found prairies of coarse grass and “scanty” timber on the limestone hills and “bald mountains.” He was most taken with the Springfield Plain and a 2-mile-wide strip of vigorous forest bordering the James River, within extensive prairies covered with tall grasses.

Nelson’s (1997) study of tree densities in various physiographic sections indicated that open woodlands were more common in the Ozarks and the Till Plain, whereas closed forests prevailed on the bottomlands of the Mississippi Alluvial Plain. Soil conditions were often described as harsh and no doubt played a role in forest structure, but fire also probably played a part (Nelson 1997). “Thinly timbered” conditions were described in 8.8 percent of GLO mile notes for the Ozarks, and an average of only eight trees per acre prevailed in these places, indicating savanna communities (Nelson 1997). Only one prairie and one glade were recorded.

Similarly, using all GLO notes in Missouri, Schroeder (1982) mapped few prairies outside of the Springfield Plain and Osage Plain. However, even some areas described as “heavily timbered” were also described as having grassy ground cover, indicating relatively open, periodically burned conditions (Ladd 1991).

Pine was especially prominent where the topography was rolling to steep and the sandstone component of the residuum was high. Inadequate winter precipitation limited pine to the southeastern part of this section. Deeper loess deposits, the presence of soil fragipans, and the Jefferson City geologic formation also were barriers to pine. The Current River Hills subsection and parts of surrounding subsections comprised the heart of shortleaf pine country in Missouri (Fletcher and McDermott 1957).

Much historic vegetation in the Ozark Highlands section remains today: upland hardwood forests, pine forests, open oak woodlands, bottomland forests, mesic hardwood forests, prairies, and even fens. Primary changes between 1819 and today are that fertile prairies have been cultivated; many of the poor prairies, barrens, and open woodlands have grown more woody and dense due to fire suppression; and most large bottomland forest areas have been inundated as a result of flood control.

Boston Mountains

Near the upper White River in the Upper Boston Mountains subsection, Gerstäcker (1881) described the vegetation:

> There was no trace of fir [cedar]; the mountains were covered with oak, beech, and hickory . . . . It struck me as extraordinary that the best and most fertile land was on the hill tops, where in other

> places, it is generally the worst; here grew black walnut, wild cherry, with stems sometimes twenty inches in diameter, black locust, and sugar maple, trees which generally grow only on the richest soils. (p. 282)

The dominant trees in the Lower Boston Mountains subsection in 1837 to 1843 were white oak, black oak, and post oak, with appreciable numbers of hickory. White oaks were most commonly on steep slopes and higher elevations. Post oaks were most commonly on high elevations, upper stream valley floodplains, and intermediate flat uplands. Black oak and hickories were distributed across all landform types (Lockhart and others 1995, Harmon and others 1996).

A comparison of the available information on historic vegetation with modern vegetation indicates fewer major historic changes than in other sections of the Highlands. However, literature on this section is skimpy, and research on historic vegetation should be a priority.

Arkansas Valley

Historically, the Eastern Arkansas Valley section was mostly forested. Further west, out of the bottomlands, were open oak woods, the ground layer of which was partly covered with grasses. Bottomlands were heavily wooded.

Near Fort Smith, prairies became predominant, with both oak- and pine-covered ridges. The Western Arkansas Valley Mountains were forested, with pine and oaks codominant. Pine was typically on south-facing and northwest-facing aspects, white oaks on northwest to northeast aspects, black oaks on west-facing slopes, and post oaks most commonly on shallow slopes. Although more open than forests of the area today, these were not savannas, although the GLO survey notes documented forests with a relatively low density and basal area, consistent with frequent burning. Savannas may have existed in smaller areas than those that may be discerned by this approach. Understory was typically described as “oak bushes,” which is indicative of periodic fire (Foti and Glenn 1991).

Nuttall (1980, but describing conditions in 1819) described the effects of intentional burning on prairies near Forth Smith in the Arkansas Valley:

> I took an agreeable walk into the adjoining prairie, which is about two miles wide and seven long. I . . . could perceive no reason for the absence of trees, except the annual conflagration . . . . The numerous rounded elevations which [checker] this verdant plain, are so many partial attempts at shrubby and arborescent vegetation, which nature has repeatedly made, and which have only been subdued by the reiterated operation of annual burning, employed by the natives, for the purpose of hunting with more facility and of affording a tender pasturage for game. (p. 158)

On his return from the Red River, Nuttall found “pine ridges” and “oak ridges” in the Western Arkansas Valley subsection (p. 164).

A botanist with Stephen Long’s expedition (James 1823) described a similar scene. Traveling east from Fort Smith, their path lay “through open woods of post oak, black jack, and hickory, occasionally traversing a narrow prairie. In these open plains, now covered with rank grass and weeds, we discovered here and there some traces, such as a skull or hoof of a bison” (p. 264). There were “heavily wooded low grounds” near present-day Paris (p. 266), while the summit of Short Mountain in that vicinity was “covered with small trees, among which the red cedar, or some other evergreen tree predominates . . . . The upland forests are almost exclusively of oak, with some . . . hickory, dogwood, and black gum. They are open, and the ground is in part covered with coarse grasses” (p. 267).

Further east, within the Central Arkansas Valley subsection, Nuttall climbed Petit Jean Mountain in 1819 and saw “a vast wilderness . . . covered with trees . . . . To the east a considerable plain stretches out, almost uninterrupted by elevations . . . . Over the vast plain immediately below me, appeared here and there belts of cypress . . . they seemed to occupy lagoons and swamps, at some remote period formed by the rivers” (pp. 120–121).

Ouachita Mountains

In the eastern part of the Ouachita Mountains, oak and pine forests of relatively small trees occurred, along with dense forests of oak, ash, and sugar maple. The historical literature and GLO surveys support the view that the forest was more open at the time of European settlement and that fires contributed to that low density (Foti and Glenn 1991). In the western Ouachita Mountains, oak savanna was documented. Only in the valleys of the western Ouachita Mountains and westernmost Fourche Mountains did prairies become dominant in the landscape. In that area, ridges were predominantly pine or oak-pine. Oaks dominated shaley rolling uplands of the Athens Piedmont Plateau subsection, while pine and stunted hardwoods were more common on the sandstone ridges.

In general, pine was virtually ubiquitous in the historic forests of the Ouachitas, but it varied greatly in dominance. Hardwoods, primarily oaks, were also a major component on most sites (Foti and Glenn 1991). On very high ridges in the western Fourche Mountains, stunted forests of white oak and post oak occurred (Nuttall 1980), while mesic forests with beech occurred in protected areas (Foti and Glenn 1991). In the more easterly Fourche Mountains and Central Ouachita Mountains, hardwoods—primarily oaks—were dominant on sandstone while pine became dominant on novaculite. In the extreme eastern Fourche Mountains, barrens dominated by stunted oaks occurred in the dry valleys. Cane grew along bottomland streams.

During an expedition to the hot springs of Arkansas in 1804 and 1805 (Rowland 1930), Dunbar and Hunter found cane along the margin of the Ouachita River within the Central Ouachita Mountains and noted that some of the hills were barren. Oak species dominated between Gulpha Creek and the hot springs, although the travelers also recorded "pine woods." From Hot Springs Mountain in what is now Hot Springs National Park, they wrote that "the timber here is not large[,] consisting of oak, pine, cedar, holly, hawthorn, with many others common to this climate, with a great variety of vines" (p. 274).

James, the botanist with the Long expedition of 1819–1820, described the Ouachita Mountains between present-day Dardanelle and Hot Springs (Fourche Mountains subsection) as covered with small and scattered trees or nearly treeless (James 1823). Oak species and Ozark chinkapin occurred on sandstone and pine forests on novaculite (p. 287). However, not all of the area James described was barren. Dense forests of oak, ash, and sugar maple occurred along the bases of mountains east of present-day Hot Springs (p. 297).

Thomas Nuttall (1980) described prairie "full of luxuriant grasses about knee high, in which we surprised herds of fleeing deer" (p. 163) in the Ouachita Mountains landscape between Fort Smith and the Red River, in what is now eastern Oklahoma (Western Ouachita Mountains subsection). On his return, he found an area of bushes and half-burnt trees along the lower Kiamichi River, which he described as "horrid, labyrinthine thickets and cane-brakes [with] very little prairie" (p. 162); he also noted hills covered in pine. He found an "extensive cove, covered with grass, and mostly a prairie of undulated surface" with thickets of greenbriar along streams at the junction of Jack Fork and Kiamichi Rivers (pp. 162–163). In the Fourche Mountains, he also described dwarf white oak forests like those currently found on the crest of Rich Mountain (p. 164).

"The barrens that lie betwixt these ridges" in the extreme eastern Fourche Mountains subsection north of Little Rock were very dry and dominated by stunted oaks (Featherstonhaugh 1844, p. 39). Similar vegetation can be seen today on National Guard Camp Joe T. Robinson in North Little Rock, along Featherstonhaugh's route. In the 1830's, pines dominated the northern Ouachita Mountains as well as the Arkansas Valley (Foti and Glenn 1991). Mesic forests occurred on north slopes. Undergrowth tended to be "oak bushes," a growth form that can result from frequent low-intensity fires. Cane apparently grew only along major rivers, and vines and briars were not common. Surveyors did not mention grass but referred to sites with "no undergrowth," perhaps indicating that there was no woody undergrowth but there was grass undergrowth, as surveyors once made this observation in the same mile where they recorded a "prairie" (Foti and Glenn 1991).

In the Western Ouachita Mountains subsection, a survey in 1896 found white oak, northern red oak, post oak, shortleaf pine, black oak, and hickories, in that order, dominant in the area. Density was low enough that the area should be described as savanna. At the same corners in 1994, dominants were shortleaf pine, white oak, mockernut hickory, northern red oak, post oak, and black oak, in that order (Kreiter 1995).

Red-cockaded woodpeckers are currently located in an area of the Fourche Mountains that had an abundance of pines in the pre-settlement forest; this area was superior habitat for the species in the past and has remained so. In 1819 and 1820, the Ouachita Mountains between present-day Dardanelle and Hot Springs (Fourche Mountains subsection) were covered with small and scattered trees or were nearly treeless (James 1823). Oak species and Ozark chinquapin occurred on sandstone with pine forests on novaculite (p. 287). However, not all of the area James described was barren. Dense forests of oak, ash, and sugar maple occurred along the bases of mountains east of Hot Springs (p. 297).

Effects of Disturbances on Highlands Ecosystems

As the prehistory and history of the Ozark-Ouachita Highlands demonstrate, climate (both long-term changes and short-term events), fire, and biotic factors, such as outbreaks of insects, are important natural disturbance factors in its ecosystems. Human-caused factors, such as flood control, introduction of nonnative species, and the prevention, suppression, or setting of fire, also can disturb ecosystems either in fairly "naturalistic" ways or in "catastrophic" ways. People have been a constant influence on plant communities and ecosystems of the Highlands, so the idea of a "natural" environment, free from human influence, is false. Human and nonhuman disturbance and vegetation in the Ozark-Ouachita Highlands are inextricably intertwined. Ecosystems change constantly as they respond to various disturbance events.

Climatic Disturbance Factors

Climate is the most important influence on vegetation in the Ozark-Ouachita Highlands. Although climate is often thought of as relatively stable, "average" climatic conditions seldom occur. (See Chapter 1 of the companion report *Aquatic Conditions* [USDA Forest Service 1999a] for a complete treatment of climatic patterns in the Highlands). Extremes of temperature and precipitation function as disturbances in particular ecosystems and may have more impact on the distribution of species than long-term averages. Native species, particularly those that are long-lived, must deal with many extreme episodes. Animal species may adjust to climatic extremes by moving to cooler, warmer, or more protected places or by becoming dormant. Plant species may respond to short-term stresses by reducing transpiration, shedding leaves, or otherwise becoming dormant, and may respond to long-term or repeated stresses with genetic changes or population shifts.

Ice and Snow

Ice and snow occasionally damage pole-sized shortleaf pines in plantations, but most native trees of the Assessment area are fairly well adapted to ice and snow. Late frosts can damage spring buds, especially in valleys subject to cold-air drainage, but rarely cause mortality. However, periodic severe ice storms cause extensive damage and are to be expected over the life span of dominant trees. This is one of the stand-replacing disturbances of the region.

Species such as loblolly pine, abundant in the Coastal Plain forests south and east of the Assessment area but only recorded in the Highlands historically in moist areas of the southernmost Ouachitas, have been widely planted in the southern half of the Highlands and are more susceptible to winter damage (Burns and Honkala 1990).

A few mountains in the Assessment area, notably Rich and Black Fork Mountains in the Ouachitas, are high and exposed enough to experience montane conditions—cold and windy, with considerable fog and ice. As a result, oaks on the crests of these mountains are stunted, only reaching heights of a few feet to about 30 feet.

Wind

The frequency, intensity, and scale of wind disturbances can cause significant variations in forest regeneration processes and resulting communities. In relatively low-intensity events, wind is responsible for "gap-phase" dynamics, the process by which a forest is renewed by death and replacement of individual trees or small groups of trees. Occasionally, severe windstorms or tornadoes destroy all or most trees within a large area, especially when preceded by soil-saturating rains.

A 19th-century traveler in Arkansas noted that tornadoes "will sweep a district of a mile in width and several miles in length, leveling everything in their path." After a time, the tornado-swept land became "impenetrable [thickets of] blackberries, thorns and creepers" important for wildlife such as bear (Gerstäcker 1881: p. 273).

Among the more notable recent blowdowns, a tornado leveled a portion of Winona Research Natural Area on the Ouachita National Forest in 1986. Its swath is still visible in young stands along the track today. In fact, high winds blow down trees in the Ouachitas nearly every year. High winds or tornadoes hit the Eleven Point District of the Mark Twain National Forest in the spring of 1997, knocking down or breaking off many oaks and pines.

Such intensive, large-scale damage is often likened to the effects of clearcutting (see Chapter 4), but windstorms seldom remove all canopy trees uniformly, nor do they cause the uniform soil disturbance often associated with site preparation. Severe storms may, however, remove virtually all canopy trees, and uprooted trees do cause significant soil disturbance.

Drought and Fire

Droughts can limit the distribution of plant and animal species. The Assessment area experiences more frequent and severe droughts than areas to the east. Droughts damaged vegetation in some areas of the Ozarks and Ouachitas in 1980 and 1981, leading to a 10 to 15 percent tree mortality in some places in 1983 and 1984 (Nelson 1985).

Drought can interact with other disturbance factors to cause greater change. For example, the phenomenon of oak decline (see Chapter 6) has been attributed in part to drought (Kessler 1992). In Missouri, overstocking of scarlet and black oaks on sites where post and white oaks and shortleaf pine are better adapted apparently contributes to drought-caused disturbance. Both competition and site adaptation may play roles here.

Wildfires, more common during drought years, can lead to the natural regeneration of new forest stands. Mattoon (1915) reported that almost all pure stands of shortleaf pine in western Arkansas (Montgomery and Pike Counties) dated from approximately 1740 or 1850. Those years may have followed ones marked by exceptionally dry periods during which stand-replacing wildfires were common. These dates roughly coincide with those of high charcoal deposition in a bog and natural lake in the western Ouachitas: fire occurrence there peaked during the Altithermal period of approximately 5,000 years before present (B.P.) and then again about 1700 B.P. and 200 B.P., but occurred throughout the record preserved in the sediments (Albert and Wyckoff 1981).

Before fire prevention and suppression became common, forests in the Assessment area typically had fewer trees, spaced much further apart, than do today's stands (Batek 1994, Schroeder and others 1997). Fire is probably the second-most important natural change process in the Highlands, following climate. Fire is a natural factor to which many species and ecosystems have adapted (USDA Forest Service 1997). The importance of fire as a landscape process in the Highlands has been emphasized by many ecologists, beginning with the study of Beilman and Brenner (1951).

The Assessment area lies at the southern and eastern edge of the Midwestern prairies, which owe their existence to climate, fire, and grazing. The pine and oak forests of the Assessment area were strongly influenced by fires as well (Spurr and Barnes 1980, Abrams 1992).

Likewise, the glades of the White River Hills—openings of tallgrass prairie in the surrounding oak woodlands—evolved with and depended upon fire as an agent of primary decomposition and nutrient recycling. Grassland plants produce fuel conditions that make fire almost inevitable, and only plant species that are extremely fire-tolerant or fire-dependent persist there.

Data on present-day lightning-set fires show a high peak in August, with high numbers also in July and September (Foti and Glenn 1991). Fires were also frequent in April, but not nearly as numerous as in August. The same general pattern was shown in the eastern Oklahoma Ouachitas, but with the highest peak in July (Masters 1994).

Society in the Ozark-Ouachita Highlands has long attempted to control the effects of fire, first by setting fires to extend its benefits and later by preventing and suppressing fires. Before European settlement, American Indians regularly set fires that burned across huge areas and stopped only at large rivers or when rain intervened (Williams 1994), apparently to thin woods, promote grazing land, and drive game into confined areas, making hunting easier.

Fire frequencies varied among the subsections of the Missouri Ozarks (Guyette and McGinnes 1982, Ladd 1991, Ladd and Huemann 1994, Nelson 1993, Rebertus 1994); the Arkansas Ozarks (Jenkins and others 1997);

and the Ouachita Mountains (Foti and Glenn 1991, Johnson and Schnell 1985, Masters and others 1994). Fire frequencies ranged from 2 to 40 years. Longer frequencies occurred during the settlement period; most frequencies are longer than the measured fire-return interval, since only fires intense enough to produce scars would be seen in the record.

In the late 1720's, Le Page du Pratz of Natchez traveled through Louisiana Territory "from the Natchez to the St. Francis" (du Pratz 1774), apparently reaching northeastern Arkansas. Although he made no specific references to fire in the Highlands, he made this general comment that may be assumed to pertain at least to the southern Highlands:

> We set out in the month of September, which is the best season of the year for beginning a journey in this country: in the first place, because, during the summer, the grass is too high for travelling; whereas in the month of September, the meadows, the grass of which is then dry, are set on fire, and the ground becomes smooth, and easy to walk on: and hence it is, that at this time, clouds of smoke are seen for several days together to extend over a long track [sic] of country; sometimes to the extent of between twenty and thirty leagues in length [a league is variously 1.6 to 3.2 miles, usually estimated at about 3 miles], by two or three leagues in breadth, more or less, according as the wind sets, and is higher or lower. (p. 134)

An "immense conflagration" occurred in an area 12 miles wide between ridges of the Ouachita Mountains in late November 1835 (Featherstonhaugh 1844, p. 36). Similarly, in Lincoln County, MO, just north of the Ozark Highlands, Joseph Mudd (1888, quoted in Ladd 1991) noted:

> Annually, after this rank growth of vegetation had become frosted, dead, and dry, the Indians set fire to it and burned it from the entire surface of the country. When this annual burning ceased, the germs of underbrush and young timber began to grow . . . .

Ladd (1991) provides many other similar descriptions.

As burning declined with European settlement, the forest's understory redeveloped rapidly. Gerstäcker (1881) described using fire to hunt deer at night: "The fire being kept behind your head, the eyes of the game will glow like balls of [fire]. [The] deer, accustomed to the frequent fires in the forest, are not alarmed" (p. 217). Gerstäcker observed in another area that "the forests not having been burnt for many years, were so thickly overgrown with underwood, that it was impossible to find the deer, or to shoot game enough to live upon" (p. 226). James (1823) noted that, "Since their occupation by permanent inhabitants, the yearly ravages of fire have been prevented, and a dense growth of oaks and elms has sprung up."

Since lightning-set fires and the fires referred to in the historic record occurred at approximately the same time (lightning-set fires concentrated in July–September and human-caused fires occurring September–November), it seems clear that American Indians did not impose a new disturbance regime, but modified the natural regime by increasing the frequency, reducing the intensity, or shifting the timing of fires to later in the autumn, when damage to vegetation was less (Foti and Glenn 1991). In general, fires can only be set when fuel is dry enough, and this is the time vegetation would burn, either from lightning strikes or anthropogenic starts. There is a smaller peak in lightning-set fires in March–April that is seldom mentioned in the historic record. Fires early in the growing season may have had much more impact on vegetation composition structure and composition than those in late summer.

Therefore, American Indians and early settlers did not produce the overall vegetation patterns of the Assessment area but rather apparently modified and emphasized the effects of lightning-caused fire (Foti and Glenn 1991). This conclusion is disputed by the studies of Kreiter (1995), however, and questioned by others.

Fire suppression became a significant disturbance factor in the Assessment area in the 1930's, as ownership of depleted farm and forestland reverted to State or Federal Governments. Reaction to damage from careless burning nationwide led to virtual exclusion of fire from all ecosystems and Smokey Bear became the symbol of forest protection. Through direct action (fire control) and indirect action (land development, grazing, reservoir construction, and logging), natural fires were for all practical purposes eliminated. As an example, fire suppression increased the fire return interval at an average site in Hot Springs National Park from 41.4 years to 1,200 years during the period 1700–1980

(Johnson and Schnell 1985). Similarly, the mean fire return interval for McCurtain County (OK) Wilderness Area increased from 29.9 years to 547 years (Masters and others 1995). In each of these cases, it should be understood that fire histories as reconstructed from fire scars underestimate the return interval. Therefore, the measured intervals are longer than the actual intervals.

In general, the forests of the Assessment area are more closed and less biologically diverse than the open oak and pine woodlands of the past. Extensive areas of pine-dominated forest are now rare in Missouri (Nigh and others 1992), and fire suppression has led to overstocking of black and scarlet oaks on sites where post and white oaks and shortleaf pine are better adapted. After 60 years of effective fire suppression, the shortleaf pine forests of the Ozarks and Ouachita Mountains are no longer open and no longer support the grass and forb understory described as characteristic of these forests in earlier times (Martin and Kline 1985, Bukenhofer and Hedrick 1997).

Oak forests also benefit from fire (even though individual trees may be damaged from an economic viewpoint). Fire helps maintain valuable timber- and mast-producing oak forests by a number of mechanisms, but especially by giving oak reproduction the competitive advantage over other species (Abrams 1992, Johnson 1993, Lorimer 1992, Van Lear and Watt 1992). (See Chapter 4 for discussion of oak silviculture.) While perhaps not as serious a problem in the relatively dry Ozarks as it is further to the north and east, oaks are gradually giving way to maples, blackgum, tulip-poplar, and other tree species on some sites (Packard 1991).

When fire is removed from a natural grassland community, fire-sensitive species such as eastern red cedar quickly invade, and fire-dependent species such as the prairie legumes and tallgrass prairie species lose vigor and dominance.

Today, under conditions greatly different than those prevalent 200 years ago, most wildfires in the Assessment area result from human accidents or arson. Between 1981 and 1996, for example, lightning caused only 2, 6, and 15 percent of the wildfires on the Mark Twain, Ozark-St. Francis, and Ouachita National Forests, respectively (table 2.1). The rates of lightning-caused fires on non-Federal lands in the Assessment area States were less than 2 percent (table 2.2).

Floods

Flash floods can have significant effects on riparian ecosystems in the Assessment area. Comparison of aerial photographs of 1935 with recent ones shows that dynamic riverside forests continually change in reaction to floods, with bands of sycamores and river birch trees moving across bottomlands as sand and gravel bars migrate. The Arkansas River submerges large bottomlands in the Arkansas Valley Section for long periods. Although levees, dams, and flood-control reservoirs in the watershed prevent or alter many of these natural

Table 2.1—Wildfires, including number of lightning-caused ignitions and acres burned, on the Highlands' national forests, 1981 through 1996

National forest	Total number of wildfires	Average annual number of fires		Acres burned
		Total	Lightning-caused	
Mark Twain	3,231	202	4	94,456
Ozark-St. Francis	1,233	77	5	20,257
Ouachita	1,689	106	16	26,810
Total	6,153	385	25	141,523

Table 2.2—Lightning-caused and human-caused fires on State and private lands from 1981 to 1996

State	Average annual lightning-caused fires	Average annual human-caused fires
Missouri	14	2,290
Arkansas	33	1,815
Oklahoma	27	1,606

Source: File records of the Arkansas Forestry Commission, Oklahoma Department of Agriculture (Forestry Division), and Missouri Department of Conservation (Forestry Division).

changes, significant areas of bottomland forest still exist along the Arkansas River and its tributaries. Floods in developed watersheds are usually more severe and destructive than those in naturally forested ones.

Studies are underway to determine how flash floods affect the Little Piney and Jack's Fork watersheds in Missouri (Jacobson 1995). Such studies may provide additional insight into an important change process.

Biotic Disturbance Factors

Biotic factors can be very significant in ecosystems, particularly as they interact with other disturbance factors. For example, southern pine beetles may not have been a serious threat to forest health as long as fire helped maintain relatively open forests and woodlands. But the insect can be a significant disturbance factor in dense pine stands.

Human introductions of nonnative species can significantly change ecosystems, as well. The gypsy moth's destruction of forests in the Eastern United States is one of the best known examples. The looming arrival of the gypsy moth "front" to the Assessment area could be an unprecedented disturbance event, with negative effects on many organisms and positive effects on others. (See Chapter 6 for discussion of biological threats to forest resources.)

In the meantime, one of the ongoing biotic disturbances of interest to public land managers and others is livestock grazing. Use of open forests, savannas, woodlands, and native grasslands for grazing occurred in the Ozark-Ouachita Highlands well before European settlement and continues today, albeit at lower levels. For early settlers on small farms in the Ozark-Ouachita Highlands, livestock was a minor to very significant source of income. Much of the livestock economy (cattle, hogs, horses, and sheep) depended upon free and unrestricted, year-round ("open-range") grazing of public lands and some private lands. Immigrants found a wide variety of such grazing opportunities in the Highlands. By the mid-1900's, enactment of laws limiting "woods burning" and development of a strong fire prevention program greatly reduced the occurrence of fires and allowed tree canopies to expand and grasses to decline in many prairies and woodlands.

Increasingly dense tree canopies and protection from fire reduced available forage on many lands in the Highlands, including the national forests. Improvement of pastures on private land, as well as conflicts with other resource uses, such as recreation, wildlife, and intensified timber management on national forests, also contributed to a decline in grazing on national forest lands (Lee 1980). Other factors contributing to the decline of range grazing in the Assessment area include legal prohibition of open-range grazing on public and private lands; increased grazing fees on national forest lands in an effort to recover "fair market value"; permittees on national forest lands reducing their operations or retiring; and the movement of younger people away from single-family farms. Still, range grazing continues to be an important biotic disturbance factor in the Highlands.

In 1992, about 13,595,600 acres of non-Federal lands within the Assessment area were devoted to grazing, down only about 5 percent compared to 1982 levels (USDA NRCS 1997). (Much of the grazing land was converted to other uses such as urban and residential expansion, agricultural crops, or timber.) On the three national forests, 131 permittees were grazing cattle in 1996, down from 401 in 1987; Animal Unit Months (AUM's) under permit declined from over 75,000 to about 28,000 during the same period (table 2.3).

The timing and intensity of grazing are key variables affecting its impacts on an ecosystem. Early and continuous overgrazing can cause the loss of topsoil by erosion and limit recovery of the vegetation. Overgrazing depletes the reserves in perennial plants and eventually kills them. In the long term, more palatable species are replaced by less palatable ones.

Table 2.3—Animal Unit Months (AUM's) and number of grazing permittees on national forests of the Highlands in 1987 and 1996

	1987		1996	
National forest	AUM's	Permittees	AUM's	Permittees
Ozark-St. Francis	20,809	112	10,262	35
Ouachita (AR)	22,742	140	4,271	34
Ouachita (OK)	8,000	33	1,438	9
Mark Twain	23,717	116	12,151	53
Total	75,268	401	28,122	131

Even light or seasonal grazing can favor the spread of certain less favorable species (Smith 1940). Penfound (1964) found protection from grazing led to rapid plant succession, decrease in forage, and increase in mulch. Hazell (1964) found heavy grazing decreased range conditions and vigor, while increasing undesirable grasses and forbs. Similarly, Jensen and Schumacher (1969) found the more desirable native bluestems decreased and less desirable species increased in numbers under long-term grazing.

Trampling by cattle can bury seeds and encourage seedling establishment. Winkel and Roundy (1991) found disturbance by cattle or mechanical methods may enhance vegetation establishment during years with moderate rainfall (depending on species and soil) but may be unnecessary during wet years. They found that during dry years it was futile to attempt to establish seedlings. Thill (1984) found cattle grazing on newly-harvested forest sites could benefit white-tailed deer by improving accessibility to sites, slowing plant succession, and possibly increasing preferred foods, such as lespedezas, by reducing competing vegetation.

Implications and Opportunities

Several points emerge from the discussion of prehistoric and more recent change: 1) constantly changing vegetation characterizes the Ozark-Ouachita Highlands; 2) the prominence of endemic species in the regional biota indicate that even during extremes of climate, refugia of oak-hickory forest existed; and 3) humans were present (having arrived some 10,000 years ago) during the assembly of "modern" communities and ecosystems and very likely influenced their structure and function.

Because people have been a constant influence on plant communities and ecosystems of the Highlands for thousands of years, ideas of "natural" (i.e., not human-influenced) conditions need to be reviewed carefully, even challenged. Human and nonhuman disturbance events are inextricably intertwined with the vegetation and wildlife of the Ozark-Ouachita Highlands. Society cannot preserve ecosystems in unchanged states, nor can it regulate them precisely to produce constant flows of desired outputs or conditions—whether those desired outputs are scenery, water, old-growth characteristics, wildlife diversity, endangered species, or wood products. Scientists face the challenge of countering long-held ecological views and public policies that ignore the consequences of disturbance and presume a constant environment.

Knowledge of how ecosystems change enables managers to take a more ecological approach to planning, implementation, and monitoring (Averill and others 1994, Pyne 1982, Williams 1993). For example, harvesting methods may mimic some types of wind-caused disturbance. Single-tree selection may mimic low-intensity wind disturbance; group selection can mimic gap-phase regeneration; and clearcutting may mimic intensive disturbance, as from a tornado (see Chapter 4).

Knowledge of "natural" fire regimes gives forest managers valuable perspective on modern questions such as whether prescribed fire is necessary in specific circumstances, when it should occur, what intensity is appropriate, and what are the most effective ways of controlling wildfires. Wildlife, aesthetic, ecological, and recreation values are served when fire is restored to glades, savannas, and woodlands. Careful monitoring of air, water, and soil qualities is an essential component of efforts to ensure that prescribed fires remain a positive overall environmental influence and that trade-offs are understood. Studies that address the effects of reintroducing fire to oak ecosystems in the Highlands would be helpful.

Similarly, information about past vegetation conditions in the Highlands may expand the options that can be considered by public land managers, research scientists, and interested citizens. Information about presettlement vegetation of the Boston Mountains is particularly sketchy. Priority should be given to increasing knowledge of historic vegetation in this section.

Expanded efforts to reintroduce the American elk to the Ozark-Ouachita Highlands deserve consideration. Populations have already been established at Cookson Hills and Pushmataha Wildlife Management Areas in Oklahoma and the Buffalo National River in Arkansas. The more widespread reintroductions of elk suggested by Bukenhofer and Hedrick (1997) would need to be undertaken carefully, taking into consideration possible diet overlaps with cattle, deer, and other species, as well as possible physical changes to the forest.

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This publication provides citizens, private and public organizations, scientists, and others with information about terrestrial animals, plants, and biological communities in and near the national forests in the Ozark-Ouachita Highlands: the Mark Twain in Missouri, the Ouachita in Arkansas and Oklahoma, and the Ozark-St. Francis National Forests in Arkansas. The document examines the status and trends of vegetation, plant and animal populations, forest management, and biological threats to forest resources in the Highlands.

Keywords: Biological threats, ecological classification, forest management, plant and animal populations, silviculture, vegetation cover.