# The Ouachita Mountain Landscape at the Time of Settlement[1]

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## Abstract

The vegetation of the Ouachita Mountain region at the time of settlement is described using historical narrative descriptions and quantitative study of General Land Office (GLO) land survey field notes of ca. 1840. Historic accounts describe the forests as similar to, but typically more open than those of the present. Extensive prairies were described in the western Ouachita Mountains. Openness of forest was often ascribed to frequent fire, either human (native American or settler) caused or natural. A single modern fire frequency study demonstrated frequent fire occurrence on a site in Hot Springs National Park ca. 1800. Data indicate that human-set fires may have altered, but did not replace, the natural fire regime. Analysis of GLO data using GRASS/GIS shows that *Pinus echinata* was generally dominant on slopes underlain by sandstone or novaculite, while *Quercus* species dominated on more level sites underlain by shale. *P. echinata* occurred primarily on moderately steep, south- or northwest-facing sites. *Q. alba* was most abundant on north-facing aspects, *Q. velutina* on west-facing, and *Q. stellata* on gentle slopes. These patterns differ from those of today in that *P. echinata* is not generally described as dominant on northwest aspects, and *Q. stellata* is usually found on steep slopes. Density and basal area in 1840 were lower than those of existing old-growth forests of the Central Hardwood Forest region. Red-cockaded woodpeckers occur today in an area which had abundant pine in the original forest.

## Introduction

A knowledge of vegetation patterns at the time of settlement (18th to mid-19th century) is needed to appropriately manage old-growth forests in the Ouachita Mountain region. Knowledge of vegetation at that time aids in the identification of

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current old growth areas and selection of appropriate management techniques. It also provides a useful baseline for evaluating the effects of management on natural systems. Differences between structure and function of existing and original forests, and between effects of management techniques and natural disturbance processes may be estimated using information on pre-settlement vegetation.

The purpose of this study is to describe the original plant community mosaic of the Ouachita region. Using historical documents, both the structure of vegetation and the disturbance processes operating at the time of settlement (with emphasis on fire and windstorm) are documented. Using field notes of General Land Office surveyors, pre-settlement distributions of dominant species are analyzed with respect to topography.

## Study Area

The Ouachita Mountains cover an area approximately 380 km east to west by 100 km north to south in western Arkansas and southeastern Oklahoma; elevations range from 100 m to 900 m (Croneis 1930). Although the Arkansas River Valley has sometimes been included in the Ouachita Mountain Physiographic Province (Croneis 1930, Fenneman 1938), we consider these as separate regions (Foti 1976, Pell 1983, Omernik 1986). General descriptions will refer to the more limited area.

The Ouachita Mountain region has ridge and valley topography. Marine sediments deposited during the early Paleozoic era were folded into ridges by continental collision during later Paleozoic (Croneis 1930, Hatcher et al. 1989). Erosion has been the dominant geological force for the last 300 million years. Ridges typically run east-west, having long north-facing and south-facing slopes. However, complex folding, faulting, and erosion have resulted in variations in slope and aspect. Typical surface rocks include sandstone, shale, and a hard siliceous rock, novaculite; limestone and other calcareous rocks are encountered frequently in the southern Ouachitas (Croneis 1930). Maximum average annual precipitation in the Ouachita Mountains is over 150 cm/yr (near Rich Mountain as a result of orographic lifting of moist south winds from the Gulf of Mexico) and minimum average annual precipitation is less than 100 cm/yr (Ark. Dept. of Planning 1973). South-facing slopes are warmer and drier than north-facing slopes because of increased insolation. Valleys are subjected to cold air drainage, and peaks are exposed to high winds and colder winter temperatures (Palmer 1924).

The typical vegetation pattern of Rich Mountain and Blackfork Mountain is "...a rather open forest..." dominated by *Pinus echinata* on the south slopes of mountains, and a mesic forest dominated by several species of *Quercus* and *Carya, Acer rubrum, A. saccharum, Castanea pumila* and others on north-facing slopes (Palmer 1924). Near the tops are open rocky glades, prairies, and there may be forests of small trees, seldom over eight or ten meters tall, with gnarled and twisted trunks and branches (Palmer 1924). These topographic variations result from differences in insolation (Johnson 1986).

In the Crystal Mountain area, *Pinus echinata* is dominant on south-facing slopes, and is controlled by steepness (Mayo and Raines 1986). On south-facing slopes, *Quercus alba* is dominant on lower slopes, *Q. marilandica* on mid-slopes, and *Q. stellata* on upper slopes (Mayo and Raines 1986). On north-facing slopes, *Q. rubra* and *Q. alba* are dominant with *Nyssa sylvatica* and *Carya tomentosa* (Mayo and Raines 1986).

The vegetation patterns at Hot Springs National Park (HSNP) are similar to those of the Crystal Mountain area but are influenced by the orientation of the pitch of strata (Palmer 1926). *Pinus taeda*, "sandy bogs" and lowland species occur in this area along streamsides and in the Ouachita River bottoms (Palmer 1926). No differences in soil or geology were found among various forest community types occurring in Hot Springs National Park; rather, slope and exposure determined soil moisture and affected species distributions (Dale and Watts 1980).

Based on fire scars on trees in transects through representative forest types, fuel loadings and topographic conditions, the fire return interval at any point in HSNP was estimated as 41.4 years, but has recently increased to 1200 years through fire suppression (Johnson and Schnell 1985). On an average site in the park, the fire-return interval was 27 years/ha (Johnson and Schnell 1985). On south, southwest, west, and northwest aspects, the mean fire-return interval was 20.5 years/ha, and on other aspects it was 33.4 years/ha (Johnson and Schnell 1985). There were not enough old trees to provide precise estimates of pre-settlement fire-return intervals. However, the oldest tree sampled, a *Pinus echinata* on a south-facing slope, experienced fires in 1788, 1798, 1806, 1811, 1817, 1829, 1847, 1857, 1873, 1889, and 1929 (Johnson and Schnell 1985). From 1788-1817 the mean fire-return interval was 7.25 years. In interpreting these figures, it should be understood that fire scars overestimate the return interval because low intensity fires do not often produce scars (Johnson and Schnell 1985).

## Methods[4]

### Historical descriptions

We reviewed primary historical sources for descriptions of vegetation and natural disturbances in the Ouachita Mountains and vicinity prior to the 20th century. The sources were limited to published accounts that have been cited in the scientific and/or historical literature.

[4] Nomenclature throughout follows Smith (1988).

**Land survey notes**

General Land Office (GLO) notes of the original land survey of the Ouachitas in the late 1830s and early 1840s provide qualitative and quantitative data on forest composition at that time. Direction and distance from each section and quarter-section corner to two or four bearing trees was measured and species were identified (Bourdo 1956). Diameter of each tree at breast height (dbh) was also measured. Location of additional line trees and qualitative descriptions of the topography, soil, forest, and undergrowth along each mile line surveyed were also recorded.

Data from the GLO were analyzed along a north-to-south 73 km transect in western Arkansas and in two rectangular study areas (figure 1). The transect line across the mountains (TRANS1) provided a regionally representative sample including 318 trees. Bee Mountain (BEE MTN) was selected because digitized elevation data was available for that area in 30 m cells. This level of detail allowed for characterization of the physiographic position (slope and aspect) of individual trees. The BEE MTN sample included 621 trees in 156 $km^2$ (1-1/2 townships). This site lies on the border of the Ouachita Mountains and the Arkansas River Valley, but primarily has the character of the Ouachitas.

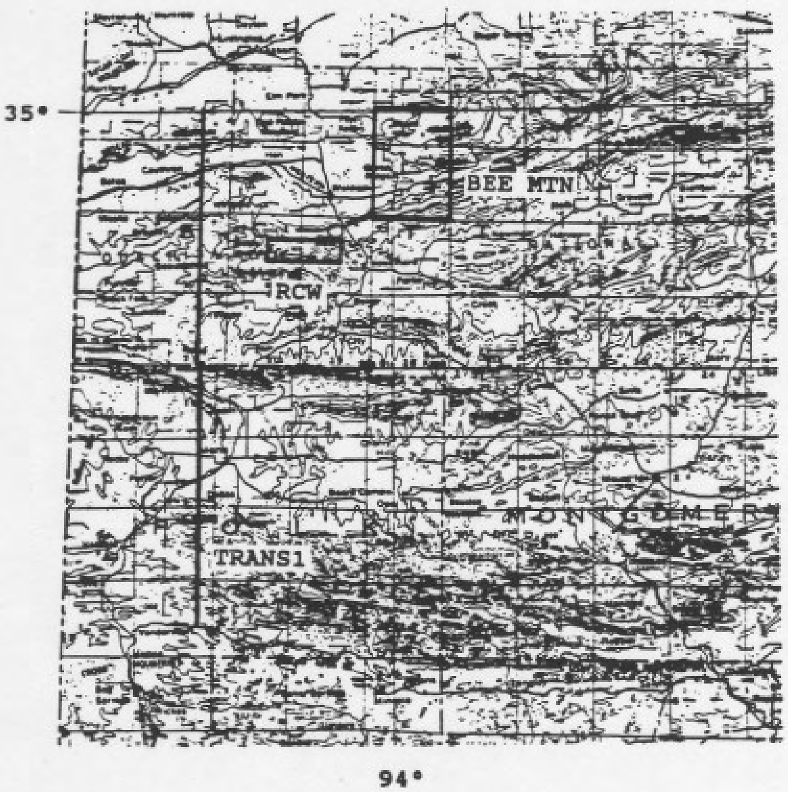


Figure 1. Study sites for analyzing General Land Office tree data ca. 1840.

The red-cockaded woodpecker site (RCW) supports several clans of this species (Ouachita National Forest file data). This may indicate that the original, as well as present, vegetation was distinctive. In the RCW site of 34.7 $km^2$, 195 trees were sampled.

Data were treated as point-centered quarter samples and used to calculate density and basal area, along with relative indices of each, for each species after the method of Cottam and Curtis (1956). Relative density and relative basal area were averaged to obtain species' importance values.

Trees were analyzed using GRASS Geographic Information System (GIS) (U.S. Army Construction Engineers Research Laboratory, Champaign, IL). Surveyor notes were digitized by obtaining the Universal Transverse Mercator (UTM) coordinates for each section corner and surveyors' direction and distance from the corners to each bearing and line tree along the ensuing mile. Using elevation data that already existed in the system, trees were sorted by slope and aspect. The proportion of the study area occupied by each combination of slope and aspect, and species frequency on that physiographic position, were calculated. Significant deviations from random species distributions across these topographic categories were tested using the Chi-square statistic (Goran et al. 1987) and used to define slopes and aspects positively or negatively associated with each species. Using the GIS, these areas were mapped for *Pinus echinata*.

### Fire regime

Monthly thunderstorm occurrence data were obtained from the National Weather Service for Little Rock, Texarkana, and Fort Smith, AR (NOAA 1980) and lightning-set fire data were obtained from the Arkansas Forestry Commission (AFC file data) and the Ouachita National Forest (ONF file data). These data were compiled over various intervals. Therefore, the data sets were combined by summing the total number of fires or thunderstorms in all sets by month. The totals were then rescaled to create a fire and a thunderstorm index for graphical comparison.

Plat maps of 42 townships in the Arkansas Ouachitas (a rectangle of 30 km by 140 km) were examined for records of prairies, fires or windstorms, all of which were commonly mapped.

## Results

### Historical descriptions

In the late 1720s, Le Page du Pratz of Natchez set out with an Indian escort to travel through Louisiana, "...from the Natchez to the St. Francis..." (Du Pratz 1774). His narrative contains numerous references to the landscape and to the effects of fire:

> 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, by two or three leagues in breadth, more or less, according as the wind sets, and is higher or lower [a league is variously 2.7-5.4 km, usually estimated at about 5 km]. In the second place, this season is the most commodious for travelling over those countries; because, by means of the rain, which ordinarily falls after the grass is burnt, the game spread themselves all over the meadows, and delight to feed on the new grass, which is the reason why travelers more easily find provisions at this time than at any other (du Pratz 1774, p. 134).

The following passage indicates that the country was open, for the parties to be able to see each other's signals at a distance of "a league":

> Every day, at nine in the morning, at noon, and at three in the afternoon, we made a smoke...in order to know, whether the scouts followed each other, and whether they were nearly at the distance agreed on (du Pratz 1774, p. 135).

Moving up the Ouachita River, he:

> ...travelled over a charming country...highly delighted with the sight of fine plains, diversified with very extensive and highly delightful meadows. The plains were intermixed with thickets...and interspersed with hills, running off in gentle declivities, and with valleys, thick set, and adorned with woods... (du Pratz 1774, p. 135ff).

At this point in the narrative, du Pratz described gypsum (found today in the lower Cretaceous deposits near the southern margin of the Ouachitas) and crystal (found within the Ouachitas), showing that he was in fact in the Ouachitas.

Later he reiterated:

> The lands we find in going up the Black [Ouachita] River...in general may be considered as one very extensive meadow, diversified with little groves, and cut only by the Black River and little brooks, bordered with wood up to their sources (du Pratz 1774, p. 169).

Dunbar and Hunter led an expedition to the hot springs in 1804 and 1805 (Rowland 1930). They described cane along the margin of the Ouachita River within the Ouachitas, with the hills sometimes barren. Between Gulpha Creek and Hot Springs the forest was dominated by oak species with few pines (Rowland 1930, p. 272). "Pine woods" were also described in this area. Species of *Quercus*, *Carya*, and *Vitis* were mentioned as being on Hot Springs Mountain (Rowland 1930, p. 278).

Edwin James, botanist for the Stephen Long expedition to the Rocky Mountains in 1819-1820, described the Ouachita Mountains between present-day Dardanelle and Hot Springs as covered with small and scattered trees or as nearly treeless (James

1823). *Quercus* species and *Castanea pumila* were found on sandstone with pine forests on novaculite (James 1823, p. 287). However, not all of the area James described was barren. Dense forests of *Quercus, Fraxinus*, and *Acer saccharum* were found along the bases of mountains east of Hot Springs (James 1823, p. 297).

Thomas Nuttall (1819) described large prairies in the valleys between the Red River and Fort Smith in the Ouachita Mountains of what is now eastern Oklahoma, as well as "pine ridges" and "oak ridges". On the lower Kiamichi, Nuttall described an area of bushes and half-burnt trees (Nuttall 1819, p. 162). Along that river were "...horrid, labyrinthine thickets and cane-brakes [with] very little prairie" (Nuttall 1819, p. 162). The hills were covered in *Pinus*. An open, hilly prairie with thickets of *Smilax* along streams was described at the junction of Jack Fork and Kiamichi rivers (Nuttall 1819, pp. 162-163). He also described dwarf *Quercus alba* forests like those currently found on the crest of Rich Mountain.

Featherstonhaugh experienced an "immense conflagration" between ridges of the Ouachita Mountains in late November (Featherstonhaugh 1844, p. 36). These areas were dominated by stunted oaks and "open wooded country" (Featherstonhaugh 1844, p. 38). Effects of a tornado were also noted (p. 104ff). In his opinion, Indian fires somewhat thinned the forests but did not destroy them and "...now that Indians have abandoned the country, the undergrowth is rapidly occupying the ground again" (p. 164ff). Fire and tornados were also mentioned by Gerstacker (1881). He referred to "frequent fires in the forest" (p. 217) but said of the sources of the Ouachita, "...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). According to Gerstacker, tornados "...will sweep a district of a mile in width and several miles in length, leveling everything in their path." After a time they became "impenetrable" thickets of "blackberries, thorns and creepers" important for wildlife such as bear (p. 273).

**Land survey notes**

**Vegetation of study sites**. Comparison of species compositions of the three study sites shows that the compositions of the BEE MTN site and the RCW site were similar, but TRANS1 crossed more habitats and included more species (table 1). Species abundance differed among all sites (table 2). BEE MTN and RCW were dominated by *Pinus echinata*, with RCW having a greater *P. echinata* component (55% vs. 38%). Three *Quercus* species co-dominated the BEE MTN site with *P. echinata* (table 2). *Pinus echinata*, made up a smaller proportion (25%) and both *Quercus alba* and *Q. velutina* had highest importance values on TRANS1 (table 2). *Quercus stellata* had its highest importance on the BEE MTN site (table 2).

Table 1. Species recorded by GLO surveyors in 1830's and 1840's in study areas in the Ouachita Mountains. Vernacular names used by surveyors, with probable scientific names.

| Species | TRANS1 | BEE MTN | RCW |
|---|---|---|---|
| Pine (*Pinus echinata*) | X | X | X |
| Post Oak (*Quercus stellata*) | X | X | X |
| Black Oak (*Q. velutina*, poss. *Q. falcata*, *Q. shumardii*, *Q. rubra*) | X | X | X |
| White Oak (*Q. alba*) | X | X | X |
| Blackjack (*Q. marilandica*) | X | X | X |
| Hickory (*Carya* spp.) | X | X | X |
| Spanish Oak (*Q. falcata*) | X | X | |
| Black Gum (*Nyssa sylvatica*) | X | X | |
| Red Oak (prob. *Q. falcata*) | X | | |
| Sweetgum (*Liquidambar styraciflua*) | X | X | |
| Elm (*Ulmus* spp.) | X | X | X |
| Dogwood (*Cornus florida*) | X | X | |
| Beech (*Fagus grandifolia*) | X | | |
| Maple (*Acer* spp.) | X | | |
| Mulberry (*Morus rubra*) | X | | |
| Ash (*Fraxinus* spp.) | X | | |
| Cottonwood (*Populus deltoides*) | X | | |

Table 2. Importance Values (Relative Abundance + Relative Basal Area)/2) of tree species on three sites in the Ouachita Mountains ca. 1840. See Table 1 for scientific nomenclature.

| Species | TRANS1 | BEE MTN | RCW |
|---|---|---|---|
| Pine | 23.60 | 38.22 | 54.66 |
| Post Oak | 14.55 | 25.11 | 19.47 |
| Black Oak | 26.01 | 17.47 | 8.46 |
| White Oak | 24.63 | 14.11 | 13.75 |
| Blackjack | 0.96 | 2.84 | 1.91 |
| Other | 10.22 | 2.22 | 1.74 |

The GIS display of species distribution showed more *Pinus echinata* on the northern half of TRANS1 than on the southern half. This is consistent with the mile summary notes of the surveyors (e.g. "mostly oak and pine" vs. "mostly pine"). This pattern may be related to geology. *Pinus echinata* abundance is reduced on the Stanley Shale

Formation along the southern portion of TRANS1 and is greater on the Atoka Formation toward the north.

While the surficial geology of Stanley Shale is predominantly shale, the Atoka Formation consists of alternating beds of sandstone and shale and ordinarily the sandstone is exposed (Croneis 1930, p. 117). Therefore, the distribution of *P. echinata* on TRANS1 may be explained by the common association of pines with sandy sites (Foti 1974). Density of trees was similar on TRANS1 and BEE MTN (100/ha); however, basal area was greater on TRANS1 than on BEE MTN because of greater average diameter (table 3). The RCW site had higher basal area than the other sites (almost 67% higher than BEE MTN); there was almost as much basal area of *Pinus echinata* on the RCW site as in the total forest of the BEE MTN site (table 3).

Table 3. Density and basal area of tree species in three sample areas in the Ouachita Mountains ca. 1840. See Table 1 for scientific nomenclature.

| | TRANS1 | | BEE MTN | | RCW | |
|---|---|---|---|---|---|---|
| Species | #/ha | $m^2$/ha | #/ha | $m^2$/ha | #/ha | $m^2$/ha |
| Pine | 16.3 | 2.45 | 33.8 | 3.56 | 59.1 | 8.42 |
| Post Oak | 19.3 | 1.56 | 28.0 | 2.27 | 42.7 | 2.72 |
| Black Oak | 26.5 | 3.70 | 18.6 | 1.43 | 14.2 | 1.06 |
| White Oak | 26.1 | 2.72 | 14.1 | 1.09 | 27.4 | 2.07 |
| Blackjack | 0.4 | 0.03 | 3.1 | 0.17 | 1.1 | 0.03 |
| Other | 11.5 | 1.19 | 2.4 | 0.11 | 3.3 | 0.11 |
| Totals | 100.1 | 11.67 | 100.0 | 8.63 | 150.0 | 14.41 |

There was mention of mesic forests on north slopes on TRANS1, e. g., two corners on north-facing slopes used *Q. alba, Q. falcata, Nyssa sylvatica,* and *Fagus grandifolia* as bearing trees. Density at these corners was 83 trees/ha, which is lower than the site average.

Undergrowth was generally described on all sites as "oak bushes". Other species that were mentioned included hickory (*Carya*), dogwood (*Cornus*), chinkapin oak (*Quercus muehlenbergii*), post oak (*Q. stellata*), blackjack (*Q. marilandica*), and black oak (*Q. velutina* or possible *Q. shumardii*). Cane (*Arundinaria gigantea*) was mentioned only along major rivers. Vines and briars were seldom mentioned. Grass was not mentioned within the study sites. However, there were several references to "no undergrowth" in the RCW and BEE MTN sites that may have meant only that there was no woody undergrowth (i.e., there was grass undergrowth), because this comment was once made in the same mile that a "prairie" was mapped.

Examination of plat maps of 42 townships revealed that prairies were mapped only within and near BEE MTN. No major burned areas, and only one tornado path was found on the maps.

**GIS analysis of species distribution at BEE MTN**

The highly-detailed digital elevation data that were available for the Bee Mountain site made possible more extensive GIS analysis of the distribution of species by topographic or physiographic position. Relationships described below are those determined to be statistically significant (Chi-square $p<.05$).

More *Pinus echinata* were found on southern and northwestern aspects and on 17°-24° slopes than if the species were distributed at random. Fewer than expected occurred on southeast, northeast, and no aspect, and on 0°-8°, 49°-61°, and 85°-90°.

When slope and aspect were analyzed simultaneously, many more *P. echinata* than expected occurred on 17°-24° north-facing and northwest-facing slopes, and fewer than expected on slopes of the same steepness facing west (table 4). There were also more *P. echinata* than expected on 9°-48° south-facing slopes (table 4). Therefore, the typical *P. echinata* site may be described as having been a moderate to steep south-facing or northwest-facing aspect. *Quercus stellata* was found most frequently (50% of trees) on slopes of less than 16°, while only 5% of the trees were on slopes steeper than 40°. There was little relationship to aspect other than fewer than expected *Q. stellata* on northeast aspects.

When sites were sorted by slope and aspect simultaneously, *Q. stellata* on less than 8° slopes were concentrated on north, northwest, west, and south aspects, while trees on 9°-16° slopes were primarily on southwest and southeast aspects (table 5).

*Quercus alba* were found mainly (63% of trees) on north, northeast, and northwest aspects. There were fewer *Q. alba* than expected on south and southwest aspects, and 9°-16° and 33°-40° slopes.

When slope and aspect were considered simultaneously, there were more *Q. alba* than expected on gentle to steep northwest-facing and on east-facing 41°-48° slopes than if the species were randomly distributed (table 6).

Examining relationships with slope and aspect separately, there were more *Quercus velutina* trees than expected on west-facing aspects and fewer than expected on south-facing aspects. There were many more *Q. velutina* trees than expected on slopes of less than 8°. Combining slope and aspect in the analysis, there were more trees than expected to occur on northwest, southwest and west slope less than 8°, and on 25°-32° west-facing slopes (table 7).

Table 4. *Pinus echinata* distribution by slope and aspect.

| SLOPE | E | NE | N | NW | W | SW | S | SE | 0 |
|---|---|---|---|---|---|---|---|---|---|
| 85°-90° | | | | | | | | | |
| 62°-84° | | | | | | | | | |
| 49°-61° | | | | | | | | | |
| 41°-48° | | | - | | | | x | | |
| 33°-40° | + | | | | | | | | |
| 25°-32° | | | | | | | + | | |
| 17°-24° | + | | x | X | - | | | | |
| 9°-16° | | | + | | | | + | - | |
| 0°- 8° | | | - | | | | | | - |

ASPECT

Legend:
- \- fewer trees than expected, Chi-Sq 2.5-5.
- \+ somewhat more trees than expected, Chi-Sq 2.5-5.
- x more trees than expected, Chi-Sq 5-10.
- X many more trees than expected, Chi-Sq >10.

All relationships significant (p<.05).

Table 5. *Quercus stellata* distribution by slope and aspect.

| SLOPE | E | NE | N | NW | W | SW | S | SE | 0 |
|---|---|---|---|---|---|---|---|---|---|
| 85°-90° | | | | | | | | | |
| 62°-84° | | | | | | | | | |
| 49°-61° | | | | | | | | | |
| 41°-48° | | | | | | | | | |
| 33°-40° | | | + | | | | | | |
| 25°-32° | | | | | | | | | |
| 17°-24° | | | | | | | | | |
| 9°-16° | | | | - | | + | | + | |
| 0°- 8° | | | X | x | + | | x | | |

ASPECT

Legend:
- \- fewer trees than expected, Chi-Sq 2.5-5.
- \+ somewhat more trees than expected, Chi-Sq 2.5-5.
- x more trees than expected, Chi-Sq 5-10.
- X many more trees than expected, Chi-Sq >10.

All relationships significant (p<.05).

Table 6. *Quercua alba* distribution by slope and aspect.

| SLOPE | E | NE | N | NW | W | SW | S | SE | 0 |
|---|---|---|---|---|---|---|---|---|---|
| 85°-90° | | | | | | | | | |
| 62°-84° | | | | | | | | | |
| 49°-61° | | | | | | | | | |
| 41°-48° | X | | | | | | | | |
| 33°-40° | | | X | x | | | | | |
| 25°-32° | | + | | X | | | | | |
| 17°-24° | | | | + | | | | | |
| 9°-16° | | | | | | | | | |
| 0°- 8° | | | | + | | | | | |

ASPECT

Legend:
- \- fewer trees than expected, Chi-Sq 2.5-5.
- \+ somewhat more trees than expected, Chi-Sq 2.5-5.
- x more trees than expected, Chi-Sq 5-10.
- X many more trees than expected, Chi-Sq >10.

All relationships significant (p<.05).

Table 7. *Quercus velutina* distribution by slope and aspect.

| SLOPE | E | NE | N | NW | W | SW | S | SE | 0 |
|---|---|---|---|---|---|---|---|---|---|
| 85°-90° | | | | | | | | | |
| 62°-84° | | | | | | | | | |
| 49°-61° | | | | | | | | | |
| 41°-48° | | | | | | | | | |
| 33°-40° | | | | | | | | | |
| 25°-32° | | | | | + | | | | |
| 17°-24° | | | | | | | | | |
| 9°-16° | | | | | | | | | |
| 0°- 8° | | | | + | + | + | | | |

ASPECT

Legend:
- \- fewer trees than expected, Chi-Sq 2.5-5.
- \+ somewhat more trees than expected, Chi-Sq 2.5-5.
- x more trees than expected, Chi-Sq 5-10.
- X many more trees than expected, Chi-Sq >10.

All relationships significant (p<.05).

**Present-day fire regime**

The historic record, already cited, includes numerous mentions of fire in the landscape, some attributed to humans, and others of uncertain origin. Data on present-day lightning-set fires show a high peak in August (with an average of 26 fires), with high numbers also in July and September (figure 2). This differs from the average monthly thunderstorm number, which had a broad peak centered in July (figure 2). Fires, but not thunderstorms, were also frequent in April (figure 2).

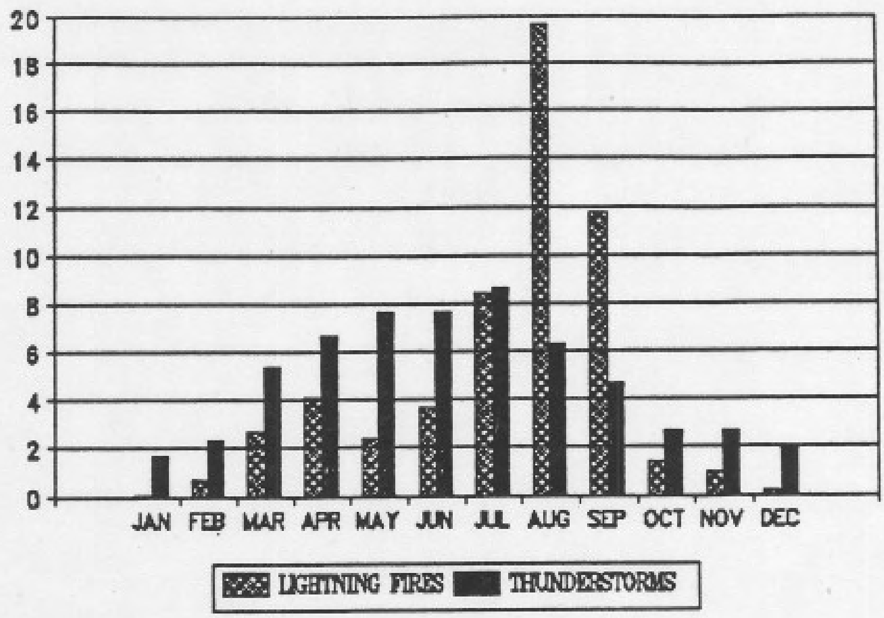


Figure 2. Frequency of thunderstorms and lightning-set fires by month.

## Discussion

The historical literature and the GLO notes demonstrate that the Ouachita Mountain region supported at the time of settlement a diversity of plant communities distributed in relationship to topographic and microclimatic factors. Each of the three study sites was dominated by a distinct assemblage of species with a distinct forest structure. Furthermore, examination of individual corner data and surveyors' mile notes show considerable geographic variation even within each of the study sites.

In comparing sites, *Pinus echinata* was virtually ubiquitous in the pre-settlement forests of the Ouachitas, but it varied greatly in dominance. Hardwoods, primarily oaks, were a major component on most sites, especially at the southern end of the TRANS1 sample. This was apparently caused by dominance of oaks on shale substrates and pine on sandstone.

Red-cockaded woodpeckers are currently located in an area (the RCW site) that had an abundance of pines in the pre-settlement forest. This area was probably superior habitat in the past and has remained so since.

Microsite distributions of individual dominant tree species documented by land survey records were generally consistent with present-day patterns. *Pinus echinata* was on south aspects and intermediate slopes, *Quercus velutina* was on west aspects, and *Q. alba* was found on north and east aspects over a wide range of slopes.

The large numbers of *P. echinata* found on northwest aspects in pre-settlement vegetation is not noted in current literature. This may have been caused by unusual local climatic conditions or disturbance regimes, or may be a characteristic of *P. echinata* distribution that has been overlooked.

The GLO distribution of *Quercus stellata* is particularly intriguing. It was strongly associated with gentle slopes and flats in the pre-settlement forests. This is inconsistent with current descriptions of its distribution which place it on steep slopes (Foti 1974, Mayo and Raines 1986, Moore 1972). This change may be a result of present-day reduced fire frequency, which has allowed less fire tolerant species to dominate the gentle slopes. Former, increased fire frequency on the level valley floors would have allowed this fire-tolerant species to dominate.

The basal areas and stem densities in the land survey data (8.6-11.6 $m^2$/ha and 100-150 stems/ha) were less than those in old growth forests of the Central Hardwood Forest (25-35 $m^2$/ha and 161-427 stems/ha - Parker 1989). This implies that old growth did not exist widely in this region, or that its structure was substantially different from eastern forests. It may also result from a bias in the surveyors' selection of young, and perhaps more distant bearing trees that were more likely to survive than closer, older trees. The historical literature supports the view that the forest was more open at the time of settlement and that fire contributed to that low density.

Although the GLO survey notes documented forests with a relatively low density and basal area, consistent with frequent burning, the forest was not typically open savanna. The density of 100 trees/ha on two sites was well above the density of 47 trees/ha proposed by Anderson and Anderson (1975) as a criterion for savanna. Nevertheless, it must be emphasized that the figures obtained in this study were of large areas and studies scaled locally would be more sensitive for identifying savanna sites.

Modern lightning-fires indicate most fires occur in August, with many in adjacent months, which is consistent with early accounts of fire. In addition, the historical literature maintains that people, both native Americans and settlers, frequently set fires. However, the frequency of fires at any one place was not enough to eliminate hardwoods, but was apparently enough to influence vegetation composition and structure. The timing of late summer and fall fires may have reduced their effectiveness in killing fire-sensitive species.

Since lightning-set fires and the fires referred to in the historic record occurred at approximately the same time (lightning-set: Jul-Sept; historic: Sept-Nov) it seems clear that humans were not imposing a new disturbance regime, but rather were modifying the natural regime by increasing the frequency, reducing the intensity, or shifting the timing to later in the Autumn when the ability of fires to kill vegetation would be reduced. Therefore the native Americans probably did not produce the overall vegetation patterns seen at and before the time of settlement, but rather modified and emphasized the patterns that resulted from the climatic fire regime.

Data developed in this study are of value in identification of old-growth communities in the Ouachita region, in guiding management of those areas, and in providing perspective on more "naturalistic" management of general forest land. It aids identification by documenting landscape patterns, species composition, site relationships, etc. It can guide old-growth management by documenting the structure of the original forests and the physical processes that shaped those forests, both of which should be maintained in old-growth management. Finally, the study can aid in developing management plans for the general forest area by identifying sites where species were likely to occur in high or low abundance under "natural" conditions. A GIS can dramatically aid this process by displaying or mapping these sites for incorporation into management plans. Forest management plans that attempt to have least impact on natural communities should relate to these patterns. Such a map can be refined to include overall species composition and the variation in compositions found on a given site so that management plans can be tailored to provide maximum landscape scale (gamma) biodiversity.

Further analysis of the existing data set will be undertaken to more clearly define both within-site and between-site variation. In addition, we recommend that all GLO records for the Ouachitas be digitized, analyzed, and incorporated into the Ouachita National Forest planning process. At the same time, existing stand conditions should be digitized for comparison. Besides the obvious management and identification value of such data, future studies can also use existing old growth forest and remaining witness or bearing trees to test the analysis and predictions based on historical field data.

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