

Woody Vegetation of Southeastern LeFlore County, Oklahoma, in Relation to Topography

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Five forest community types were recognized in the four proposed Wilderness Areas in the Oklahoma portion of the Ouachita National Forest. Woody species composition of the community types is significantly correlated with elevation and an insolation index calculated from slope and aspect. Tree basal area is significantly correlated with elevation. The four areas are recommended for designation as Wilderness Areas.

INTRODUCTION

Four large, essentially roadless, and relatively undisturbed areas in the Oklahoma portion of the Ouachita National Forest meet the criteria for wilderness set forth by Public Law 93-622, commonly known as the Eastern Wilderness Act. Two of the areas have been recommended by the U.S. Forest Service (1) for designation as Wilderness Areas under provisions of the Act. Several organizations concerned with conservation and wildlife protection have recommended inclusion of all four areas in the national wilderness system. Official designation of an area as wilderness requires action by the U.S. Congress, which has not yet acted on an Oklahoma wilderness bill.

The four areas are all in southeastern LeFlore County. Several tree and shrub species reach the western limit of their distribution in the area (2). Upland forests of the region have been described as oak-pine or oak-hickory-pine (3, 4, 5), but quantitative sampling of the vegetation has not been done.

I undertook the present study in order to investigate the influence of topography on the woody species composition of the forests of the region and to provide a quantitative description of the woody vegetation of the four potential wilderness areas.

STUDY AREA

The four areas under consideration are in the Ouachita National Forest near the Oklahoma-Arkansas border. The sites are in the Ouachita Mountains, which (in southeastern LeFlore County) consist of long linear east-west trending ridges which reach altitudes of 800 m with the intervening valleys at an elevation of about 300 m. Surface rocks are mostly sandstones and shales (6). The general area is in the Oak-Pine vegetation type of Duck and Fletcher (7). The climate is classified as Humid Subtropical (8), with annual precipitation of 135 cm and mean annual temperature of 17.2 °C. (9). However, microclimates in mountainous regions vary considerably from the regional climate because of differences in slope, aspect, and elevation (10).

The Beech Creek Area covers 3250 ha and includes most of the watershed of Beech Creek, which is made up of the floodplain of Beech Creek, the north-facing slope of Walnut Mountain, and the south-facing slopes of Blue Bouncer Mountain and Lynn Mountain. The Upper Kiamichi Area covers 3570 ha and includes most of Pine Mountain, the source and several kilometers of the upper Kiamichi River, and much of the south-facing slope of Rich Mountain. The Rich Mountain Area covers 2040 ha and includes most of the Oklahoma portion of the north-facing slope of Rich Mountain. The Black Fork Area covers 1775 ha and includes most of the Oklahoma portion of Black Fork Mountain and part of the Big Creek Valley. The Black Fork Area adjoins and is considered an extension of the existing Black Fork Wilderness in Arkansas.

METHODS

Site selection

Because of the east-west orientation of the long ridges in the area, only four topographic types were considered to be important in this study. They are: valley bottom-floodplain, south-facing slope,

ridgetop, and north-facing slope. Other topographic types exist, but they cover relatively small areas and were not sampled. A set of 18 sites was selected in the proposed wilderness areas to obtain at least three sites in each of the four major topographic types. Seven sites were sampled on north-facing slopes because a preliminary survey indicated greater variation in species composition on these sites.

Field sampling

At each site, 30 sampling points were chosen with a stratified random design in a portion of the site considered to be representative. At each point, trees (defined as woody stems with dbh ≥ 5 cm) were sampled for density, frequency, and basal area with an augmented variable-radius method (11) in which basal area was estimated with a two-factor metric forester's prism (12) and trees were counted by species in an 18.3-m diameter circular plot. Woody plants with a dbh < 5 cm (saplings, tree seedlings, shrubs, and woody vines) were counted by species in a 6.1-m diameter circular plot for frequency and density estimates. Numbers of samples and plot sizes were chosen to reduce the standard error of tree density to less than 20% of the mean, on the basis of previous experience in forest sampling.

Data analysis

Field data were used to calculate standard phytosociological data (13): density, frequency, and basal area of tree species; and density and frequency of small woody species. Importance values were obtained for each tree species by calculating the mean of the relative density, relative frequency, and relative basal area (expressed as percent). Importance values for shrubs and vines were calculated as the mean of relative density and relative frequency. The Shannon-Wiener diversity index (14) and an evenness index (15) were calculated from relative density data for trees. Diversity and evenness were not calculated for shrubs and vines since some were only identified to genus.

Reciprocal averaging ordinations (16) were done separately for trees and for shrubs and vines, using importance values. The data were not transformed and minor species were not eliminated or downweighted in the ordination results presented below.

For each site, average slope, aspect, and elevation were determined from 7.5' topographic maps and a relative insolation (RI) index was calculated from the slope and aspect. The RI was defined as the mean ratio of the length of a shadow falling on a slope to the length of the same shadow falling on a horizontal plane, calculated at noon on the solstices and equinoxes. Product-moment correlation coefficients (17) were calculated for elevation and RI with tree density, tree basal area, shrub and vine density, and ordination axis positions.

RESULTS AND DISCUSSION

The ordination based on tree species (Fig. 1), which was derived entirely from quantitative vegetation data, resulted in a grouping of the sites that is consistent with the topographic positions of the stands. It also confirms subjective impressions formed from field observations. The ordination placed sixteen of the sites into four distinct groups: ridgetop (TOP), upper and middle north-facing slope (UMN), valley bottom-floodplain (BOT), and south-facing slope (S). The other two sites were from lower north-facing slopes (LN) and were placed between the BOT and S groups. The ordination based on shrub and vine species, which is not shown, resulted in the same

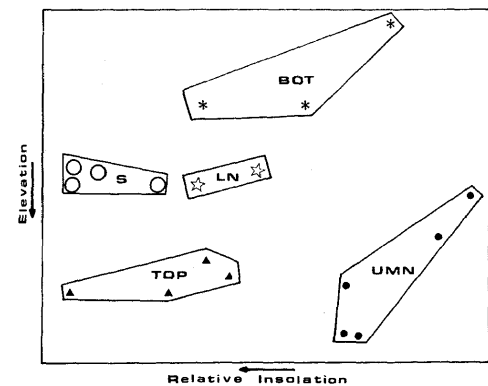


FIGURE 1. Reciprocal averaging ordination of the 18 sites. Abbreviations: BOT = valley bottom-floodplain, UMN = upper and middle north-facing slope, LN = lower north-facing slope, S = south-facing slope, TOP = ridgetop. Polygons drawn around the groups are only visual aids and do not imply precise group boundaries.

grouping of sites as the tree ordination.

The first axis of the ordination based on tree species had a product-moment correlation of -0.761 ($p < 0.01$) with the relative insolation (RI) index and the second axis had a correlation of -0.789 ($p < 0.01$) with elevation. In the ordination based on shrubs and vines, the first axis had a correlation of -0.807 with RI and the second axis had a correlation of 0.620 with elevation.

A list of the 37 tree species encountered in the sample plots and their importance percentages in the five community types is given in Table 1. A similar list of the 19 species/genera of shrubs and woody vines is given in Table 2. Latin names correspond to those given by Waterfall (18), except for the two species of *Tilia*, which were determined from a key given by Lawson (19). Most of the tree species encountered are easily identified without a close, time-consuming examination. However, the linden (*Tilia*) species and the northern red oak-Shumard's oak (*Quercus rubra*-*Q. shumardii*) pair present some difficulty when many trees are encountered. Of the lindens that were closely examined, *Tilia americana* was found only in the valley bottom-floodplain community and *T. caroliniana* on the north-facing slopes and ridgetops. None of the oak trees which were closely examined appeared to be northern red oak, although Palmer (3) reported that both northern red oak and Shumard's oak were common on Rich Mountain.

Although many of the tree species occurred in all five community types, most species reached a definite maximum in one type. Species which were found in more or less equal numbers in the five types are dogwood (*Cornus florida*), serviceberry (*Amelanchier arborea*), red maple (*Acer rubrum*) American elm (*Ulmus americana*), and black cherry (*Prunus serotina*).

The valley bottom-floodplain community (BOT) had 24 species, with no species being dominant (importance percentage ≥ 20). This community offers a diversity of habitats, from creek margins and sloughs to gentle but rocky and well-drained slopes, which is reflected in the diversity of vegetation. Several tree species are important in most stands, including sugar maple (*Acer saccharum*), bitternut hickory (*Carya cordiformis*), sweet gum (*Liquidambar styraciflua*), ironwood (*Ostrya virginiana*), Shumard's oak, and white oak (*Q. alba*). A few large shortleaf pines (*Pinus echinata*) are found scattered throughout this type. American beech (*Fagus grandifolia*), which reaches the western limit of its distribution in eastern LeFlore County, is common along Beech Creek and a few individuals can be found along the upper Kiamichi River and Big Creek. Shrubs and vines are abundant ($\approx 5500/\text{ha}$), the most important of which are briars (*Smilax* spp.) and poison ivy (*Rhus radicans*).

The forest community found on upper and middle north-facing slopes (UMN) has many tree species, but species diversity is much lower than in the BOT community because of the strong dominance of mockernut (*Carya tomentosa*), which has an importance of over 50% in some stands. The only other tree species with importance greater than 10% are linden (*Tilia caroliniana*) and white oak, although 10 species have their maximum importance in this type (Table 1). Another tree species that reaches the western limit of its distribution in this area is cucumber tree (*Magnolia acuminata*), which is abundant at some sites on the upper north-facing slope of Rich Mountain but absent from very similar sites on the north side of Black Fork Mountain. Pine is absent and the oaks reach their lowest importance in this type. The most important shrubs and vines are coralberry (*Symphoricarpos orbiculatus*), Virginia creeper (*Parthenocissus quinquefolia*), and poison ivy.

The sites on lower north-facing slopes (LN) have tree vegetation that is somewhat intermediate to that of the BOT and S types. The most important tree species is Shumard's oak, which also has a higher importance value here than in any of the other types. Other important tree species are mockernut, red maple (*Acer rubrum*), black gum (*Nyssa sylvatica*), pine, and white oak. The most important shrub and vine species in this type are poison ivy, brier, witch hazel (*Hamamelis virginiana*), and sugar huckleberry (*Vaccinium vacillans*).

The vegetation of south-facing slopes (S) is typical oak-pine forest, with shortleaf pine accounting for about 30% of the tree

TABLE 1. Mean tree species importance values for the five major community types. Abbreviations:
 * = highest importance percentage for the species; other abbreviations are the same as in Fig. 1.

SPECIES	BOT	UMN	LN	S	TOP
<i>Acer saccharum</i>	8.8*	5.6	2.2	0.5	
<i>Carpinus caroliniana</i>	1.5*				
<i>Carya cordiformis</i>	13.9*				
<i>Crataegus crus-galli</i>	0.2*				
<i>Fagus grandifolia</i>	2.2*				
<i>Fraxinus pennsylvanica</i>	0.8*				
<i>Ilex opaca</i>	1.6*				
<i>Liquidambar styraciflua</i>	9.8*		7.9	2.8	
<i>Ostrya virginiana</i>	7.1*	3.6	2.9	0.1	0.4
<i>Platanus occidentalis</i>	0.8*				
<i>Quercus falcata</i>	0.2*				
<i>Tilia americana</i>	3.5*				
<i>Vaccinium arboreum</i>	0.1*				
<i>Carya tomentosa</i>		32.6*	13.0	2.8	12.9
<i>Cercis canadensis</i>		0.1*			
<i>Fraxinus americana</i>		3.8*			0.2
<i>Juglans nigra</i>		2.8*			
<i>Magnolia acuminata</i>		2.8*	2.3	0.1	
<i>Morus rubra</i>		0.2*			
<i>Prunus serotina</i>	2.6	5.5*	2.9	0.7	4.3
<i>Robinia pseudoacacia</i>	0.2	0.6*		0.1	0.1
<i>Tilia caroliniana</i>		10.1*	0.8		
<i>Ulmus americana</i>	1.2	4.2*	0.5	1.2	0.6
<i>Viburnum prunifolium</i>		0.1*			
<i>Acer rubrum</i>	3.3	0.1	8.0*	4.7	3.0
<i>Amelanchier arborea</i>	0.3	0.1	2.0*	1.3	0.5
<i>Nyssa sylvatica</i>	5.0	0.5	9.0*	7.4	2.0
<i>Quercus shumardii</i>	15.9	6.2	19.4*	11.0	5.3
<i>Pinus echinata</i>	5.7		11.3	28.7*	1.9
<i>Quercus marilandica</i>				1.2*	1.0
<i>Quercus stellata</i>				4.2*	3.3
<i>Quercus velutina</i>			0.8	11.8*	4.4
<i>Bumelia lanuginosa</i>	0.1				0.7*
<i>Carya texana</i>				2.9	7.0*
<i>Cornus florida</i>	1.0	1.4	1.1	0.5	2.4*
<i>Quercus alba</i>	13.9	10.9	15.0	17.8	49.1*
<i>Sassafras albidum</i>		0.4			0.7*
Density, trees/ha	610	556	607	625	598
Basal area, m ² /ha	23.2	18.8	18.4	21.6	15.1
Diversity	2.22	1.78	2.25	1.92	1.42
Evenness	0.79	0.68	0.82	0.73	0.59

importance value and the oaks totaling another 45%. Several of the tree species such as post oak (*Q. stellata*), blackjack (*Q. marilandica*), black oak (*Q. velutina*), and black hickory (*Carya texana*) are considered to be characteristic of xeric habitats (5). The shrub and vine component of the vegetation is strongly dominated by sugar huckleberry, which accounts for almost two-thirds of the small woody vegetation. The only other important component of the shrub-vine stratum is brier.

The ridgetop community (TOP) is somewhat variable, depending on whether the ridge crest is sharp and rocky or broad and level. However, the community is usually strongly dominated by white oak. Much of the ridgetop community is on a more or less broad and nearly level ridge crest, and consists of a dense stand of white oak and

TABLE 2. Mean shrub and vine importance values for the five major community types. Abbreviations are the same as in Fig. 1.

SPECIES	BOT	UMN	LN	S	TOP
<i>Alnus serrulata</i>	0.4*				
<i>Smilax</i> spp.	45.5*	8.8	20.8	24.4	14.7
<i>Aesculus glabra</i>		4.0*			
<i>Asimina triloba</i>	0.6	4.8*	0.7		0.2
<i>Hydrangea arborescens</i>		1.7*			
<i>Lindera benzoin</i>		1.1*			
<i>Parthenocissus quinquefolia</i>	10.9	17.5*			3.1
<i>Rosa</i> sp.		0.4*			
<i>Sambucus canadensis</i>		0.3*			
<i>Symphoricarpos orbiculatus</i>		30.2*			
<i>Rhus radicans</i>	22.6	14.8	33.7*	1.4	0.9
<i>Vaccinium vacillans</i>	10.4	1.4	17.3	64.9*	24.4
<i>Vitis</i> spp.	7.8	2.8	6.1	8.0*	0.2
<i>Chionanthus virginicus</i>				0.5	10.5*
<i>Hamamelis virginiana</i>	2.3	2.5	20.7	0.5	23.3*
<i>Hypericum densiflorum</i>			0.7		3.4*
<i>Rhododendron canadense</i>					2.1*
<i>Rhus copallina</i>				0.4	2.2*
<i>Rubus</i> spp.		9.7			14.5*
Density, stems/ha	5479	3133	3295	3385	4631

mockernut about 5 to 7 m tall. The highest, narrowest ridgetops on Rich and Black Fork Mountains are covered with small distorted white oaks, blackjacks, post oaks, and black hickories about 2 to 3 m tall, with grassy openings and occasional boulder fields. Many of the trees on and near the ridge crests have broken tops and branches, a condition which suggests severe wind and/or ice conditions. The shrub and vine stratum is dominated by sugar huckleberry and witch hazel, with brier, old man's beard (*Chionanthus virginicus*), and blackberry (*Rubus* spp.) important on some sites.

There are no striking differences between the communities in numbers (density) of trees, except for the openings on some of the ridge crests. No significant correlation was found between either of the topographic indexes and tree or shrub density. However, the trees reach much larger size in the valley bottom-floodplain community, which results in high basal area. Conversely, the trees on the ridgetops are small and basal area is consequently low (Table 1). The relatively high tree basal area in the south slope community is mostly a result of the large size of the pines, many of which are 50 to 60 cm dbh in old-growth sites. Most hardwood trees on the south-facing slopes are much smaller than the pines. Correlation of tree basal area with elevation was -0.484 ($p < 0.05$).

Diversity and evenness of the tree stratum are highest in the BOT and LN communities because no species is dominant on most of the sites. The TOP community, which has a relatively large number of tree species, has a low diversity index because of the very strong dominance by white oak.

CONCLUSIONS

Topographic position (elevation, slope, and aspect) has a strong influence on species composition of the forests in the area. While some tree, shrub, and vine species are ubiquitous, others are restricted to one or two of the community types. The species restricted to the UMN and BOT communities are those that are considered to have high water requirements or that are adapted to the complex of conditions called "mesic". The species restricted to the S and TOP communities are those that are apparently adapted to "xeric" conditions. Prevailing winds in the region are from the southwest (9), which combines with the larger amounts of insolation to make the south-facing slopes and ridgetops warmer and dryer, and the north-facing slopes and valley bottoms cooler and more humid, than the regional climate.

Sites on the south-facing slopes are good examples of the oak-pine vegetation type. Sites on the upper and middle north-facing slopes are a somewhat unusual variation of the oak-hickory type, since they are strongly dominated by hickory and have relatively small amounts of oak. The other topographic types could be said to have oak-pine or oak-hickory-pine forests, since oaks are dominant and hickories and pines are present in at least small numbers.

I consider the four areas under consideration to be worthwhile for inclusion in the Wilderness System. All four areas are relatively undisturbed and provide good examples of pre-settlement conditions in the Ouachita Mountains. In addition, the Beech Creek and Rich Mountain areas contain vegetation that is very unusual for Oklahoma.

REFERENCES

1. U.S. Forest Service, *Proposed land and resource management plan, Ouachita National Forest*, U.S. Dept. of Agric., Forest Serv., Ouachita Natl. For., Hot Springs, AR, 1985.
2. E.L. Little, Jr., *Forest Trees of Oklahoma*, Okla. Forestry Div., State Dept. of Agric., Oklahoma City, 1981.
3. E.J. Palmer, *J. Arnold Arb.* 5: 108-134 (1924).
4. W.E. Bruner, *Ecol. Monogr.* 1: 99-188 (1931).
5. E.L. Rice and W.T. Penfound, *Ecology* 40: 593-608 (1959).
6. C.B. Hunt, *Natural Regions of the United States and Canada*, W.H. Freeman Co., San Francisco, 1974.
7. L.G. Duck and J.B. Fletcher, *A game type map of Oklahoma*, Okla. Game and Fish Dept., Okla. City, 1943.
8. G.T. Trewartha, *An Introduction to Climate*, McGraw-Hill, New York, 1968.
9. B.R. Curry, *Climate of Oklahoma*, U.S. Dept. of Commerce/ESSA/Environ. Data Serv., Silver Spring, MD, 1970.
10. R. Geiger, *The Climate Near the Ground*, Harvard Univ. Press, Cambridge, MA, 1950.
11. E.L. Rice and W.T. Penfound, *Ecology* 36: 315-320 (1955).
12. D. Bruce, *J. Forestry* 53: 163-167 (1955).
13. G.W. Cox, *Laboratory Manual of General Ecology*, Wm. C. Brown Co., Dubuque, IA, 1967.
14. C.E. Shannon and W. Weaver, *The Mathematical Theory of Communication*, Univ. Illinois Press, Urbana, 1949.
15. E.C. Pielou, *Ecological Diversity*, Wiley-Interscience, New York, 1975.
16. H.G. Gauch, R.H. Whittaker, and T.R. Wentworth, *J. Ecol.* 65: 157-174 (1977).
17. R.R. Sokal and F.J. Rohlf, *Biometry*, W.H. Freeman Co., San Francisco, 1981.
18. U.T. Waterfall, *Keys to the Flora of Oklahoma*, published by the author, Stillwater, OK, 1972.
19. C.A. Lawson, *Proc. Okla. Acad. Sci.* 50: 104-105 (1970).