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**THE EFFECT OF SLOPE-ASPECT
ON THE
COMPOSITION AND DENSITY OF AN
OAK-HICKORY FOREST
IN
EASTERN KANSAS**

By

Rodney Birdsell and J. L. Hamrick

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The Effect of Slope-Aspect on the Composition and Density of an Oak-Hickory Forest In Eastern Kansas

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ABSTRACT

Measures of species-diversity, basal area, Importance-Values of individual species and the presence or absence of individual species of trees were compared for north- and south-facing slopes in northeastern Kansas. Basswood (*Tilia americana*) was present only on north-facing slopes. Black walnut (*Juglans nigra*), redbud (*Cercis canadensis*) and bur oak (*Quercus macrocarpa*) were more frequent on north-facing than on south-facing slopes. Red oak (*Quercus rubra*), white ash (*Fraxinus americana*), red elm (*Ulmus rubra*), black oak (*Quercus velutina*), shagbark hickory (*Carya ovata*) and hackberry (*Celtis occidentalis*) were more often present on south-facing slopes. The chestnut oak (*Quercus muhlenbergii*) was found equally distributed on north-facing and south-facing slopes. The more important species present are red oak, black walnut, white ash and shagbark hickory. Previous importance of elms, especially American elm, has been reduced, largely because of the Dutch Elm Disease. North-facing slopes differed from south-facing slopes for all measurements, except for average basal area and overall diversities. The hypothesis is presented that slope-differences are due to the microclimatic variations inherent to the slope-aspect. Biogeographical evidence is given and discussed to support this hypothesis.

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INTRODUCTION

Vegetation varies in response to environmental parameters (Boughley, 1973). At the margins of plant communities these responses may be dramatic, with only slight environmental changes producing marked changes in the dominant vegetation. Such areas occur in northeastern Kansas where sharp ecotones exist between the oak-hickory and the tall-grass-prairie vegetations. Before the arrival of white settlers in the 1850's, these two types of vegetation overlapped in an interdigitating pattern that was determined by various environmental factors (Fitch and McGregor, 1956). Of these factors, availability of moisture is usually considered to be the most important in limiting the extent of oak-hickory forest in eastern Kansas (Weaver et al., 1925). However, changes in environmental parameters such as slope-aspect or edaphic factors may produce subtle but measurable changes in the dominant vegetation.

In this paper, we describe variation in the dominant forest-canopy within the forest-prairie ecotone region of northeastern Kansas and we present the hypothesis that dissimilarities found between the vegetation of north- and south-facing slopes are due to differences in the available moisture inherent to the slope-aspect.

MATERIALS AND METHODS

The study area is a ravine on the John H. Nelson Environmental Study Area (NESA) and is located approximately 15 km. north of Lawrence, Kansas, in southeastern Jefferson County. The longitude and latitude of the area are $90^{\circ} 12' W$ and $34^{\circ} 03' N$, respectively, and the elevation is approximately 310 meters (1017 feet).

The ravine runs in a westerly direction, forming north- and south-facing slopes with a maximum topographic gradient of 16.8 meters (55 feet). To the

north and south of the ravine are areas of grassland, whose management prevents the invasion of woody vegetation. Thus, the only established forest vegetation is either in the ravine or directly adjacent to it.

Three line-transects were established in a north-south direction perpendicular to the direction of the ravine. The transects consisted of trees tagged at breast height with numbered aluminum tags, and served as guidelines for the location of the sample plots. The lengths of the transects, the width of the forest vegetation, are, from east to west, approximately 110 meters, 140 meters, and 250 meters.

Since the transects varied in length, differing numbers of sample plots were systematically placed along each transect. On the eastern transect two 10×10 m plots were established, one on the north-facing slope and one on the south-facing slope. The central transect contained a similarly placed pair of plots, plus a third plot located on top of a limestone-outcrop adjacent to the south-facing slope. The western transect consisted of two south-facing and two north-facing plots. Of these four plots, two were located on limestone-outcrops and two were located on the slope below. Thus, a total of nine plots were established, four on the north-facing slope, four on the south-facing slope, and one on a flat area adjacent to the south-facing slope. Within each plot, each tree larger than three inches in diameter at breast height (DBH) was identified to species, was numbered with an aluminum tag, and its DBH was recorded.

From the DBH data, basal areas were calculated for each plot. The basal area for the surrounding woodland was obtained by the Bitterlich Variable-Radius Technique (Cox, 1967). The two basal area measurements were compared to determine if the woodland density for the

plot was representative of the area in which it was located. For each species, the relative density, relative frequency, relative dominance, and Importance-Value were calculated for each plot and for the north- and south-facing slopes.

The Shannon-Weiner Index of Species-Diversity was utilized as a measure of species-diversity. The index is given by

$$H' = -\sum_{i=1}^S p_i \ln p_i, \text{ where } H' \text{ is the index of}$$

species diversity for a group of S species, p_i is the relative abundance of i th species, and $\ln p_i$ is the natural logarithm of p_i . Species-diversity for each plot was calculated, and north- and south-facing slopes were compared. In addition to species-diversity, species-abundance (J') was calculated by $J' = H'/\ln S$ (Tramer, 1969), where H' is the Shannon-Weiner Index of Species-Diversity and S is the number of species present.

Data were also obtained from two extraneous sources. An analysis of the physical and chemical soil properties for NESA was conducted during the fall of 1975, and aerial photos from 1941 and 1973 were obtained from the Kansas State Geological Survey.

RESULTS

Six of the nine plots were located on soils mapped either as "Steep and Stony" or as "Detlor Complex," the primary difference being steepness of slope, with 20-45% and 8-18% respectively (USDA, 1977); there were no major chemical differences found for any of the plots. Both soil-mapping units were formed over colluvial material from the limestone-outcrops. The one plot on top of the limestone-outcrop was in the Oska soil series. Except for the two plots located directly on the limestone-outcrops, the eight plots analyzed in association with slope-aspect can be assumed to contain no significant variation in soil quality.

Table 1 ranks all species according to their overall Importance-Values. The more important species were red oak (*Quercus rubra*), black walnut (*Juglans nigra*), white ash (*Fraxinus americana*) and shagbark hickory (*Carya ovata*). The sum of the Importance-Values for these four species was 201.6 (of a possible total of 300). Of these four species, three showed a marked preference for one or the other slope-aspect. The lone exception was red oak, which had only a slightly higher Importance-Value on the south-facing slope. Black walnut had a definite preference for the north-facing slope, while white ash and shagbark hickory favored the south-facing slopes. Marked slope preferences were also shown by species with intermediate or low Importance-Values. The most remarkable of these was basswood (*Tilia americana*) which had an Importance-Value of 46.8 on the north-facing slope, but did not appear on the south-facing slope. Bur Oak (*Q. macrocarpa*) and redbud (*Cercis canadensis*) also had higher Importance-Values on the north-facing slope. Red elm (*Ulmus rubra*), black oak (*Q. velutina*), and hackberry (*Celtis occidentalis*) preferred the south-facing slopes. Only chestnut oak (*Q. muhlenbergii*) failed to demonstrate a slope-preference. Thus, although the coefficient of community of the two slopes was relatively high (0.658 as compared to an expected value of 0.850; Cox, 1972), there is a marked difference in species composition between the two slopes.

Both numbers of individuals and the total basal area were similar in the majority of plots (Table 2). Two plots (1 and 4) were similar to the other plots in terms of total basal area, but, as a result of having few individuals, the average basal area per individual was relatively high. The two plots on the limestone-outcrop (6 and 9) contained numbers of

individuals roughly equal to the other plots, but since each individual tree was relatively large, the total basal area was also large. The total basal area measurements obtained by the Bitterlich technique were similar to those obtained by actual individual measurements except for the two plots on limestone-outcrops. Both of these plots yielded Bitterlich basal area estimates of roughly half that actually present, primarily due to the narrowness of the vegetation directly affected by the outcrops.

Generally, individuals on the north-facing slope were larger than those on the south-facing slope. The ratio between the respective mean basal areas compares favorably with that found in New Jersey by Cantlon in a study on Cushtunk Mountain (Kormondy, 1969). Individuals on the north-facing slope of Cushtunk Mountain averaged 1.8 times greater in basal area than those on the south-facing slope. Individuals on the north-facing slope in the NESA ravine averaged 1.4 times greater in size than those on the south-facing slope.

In contrast to the basal-area differences, the age of the stand appears to be approximately equal for all plots except those on the limestone-outcrops. Aerial photographs from 1941 show little or no forest vegetation within the study area, with the exception of the rock outcrops. The age of the forest can thus be taken to be somewhat less than 40 years.

Both species-richness and species-abundance were measured by the Shannon-Weiner Index of Species-Diversity. Species-richness, or the number of species present, ranged from three species per plot to six species per plot. Although neither slope contained substantially greater numbers of species per plot, certain species (especially basswood) did demonstrate a slope preference. The species-abundance factor (J') was slightly higher for the

north-facing plots than for the corresponding south-facing plots, indicating that north-facing plots possess a more nearly equal distribution of species.

DISCUSSION

The most dramatic effect of slope-aspect is the variation in individual species' Importance-Values (Table 1). Of the eleven species found, the three demonstrating the more widely variable Importance-Values were basswood, white ash, and black walnut. Basswood appeared only on the northfacing slope, yet possessed the third Importance-Value for that slope, being surpassed only by black walnut and red oak. Furthermore, only basswood demonstrated a strong slope-preference and a strong preference for the number of plots on which it appeared.

Of the three species demonstrating a major slope-preference, basswood has the most limited geographical distribution (Little, 1971). Within the forest-prairie ecotonal region of eastern Kansas, the major environmental parameter limiting the western distribution of basswood is precipitation. It therefore follows that micro-climatic heterogeneity in moisture-availability should be reflected by micro-distributional patterns of basswood more than for species with greater ecological amplitudes.

This result is consistent with several studies which reveal that north-facing slopes remain cooler and contain more moisture than corresponding south-facing slopes. In one such study conducted in Michigan during the 1957 growing season (Cooper, 1960), the air-temperature fifty cm. above the ground averaged nearly 5°F higher on the south-facing slope than on the north-facing slope. In addition, soil-temperatures at depths of 2 and 20 cm. produced similar differences, and the percent of moisture (by weight) of the soil at a depth of 2 cm. was as much as

12.7% higher for the north-facing slope. Thus, the north-facing slope was better able to supply moisture to the vegetation during periods of stress by drought.

A similar study by Cantlon on Cushe-tunk Mountain in New Jersey lists temperatures from 3.5-6.0°F higher for the south-facing slope than for the north-facing slope (Kormondy, 1969). As a result of the higher temperatures, the south-facing slope has a larger vapor-pressure deficit, and more evaporation. Even greater extremes in the microclimate have been shown to exist between northeast- and southwest-facing slopes (Benson et al., 1967). Therefore, in eastern Kansas where water availability is one of the more important environmental parameters influencing vegetational composition, it is not surprising to find mesophytic species restricted to north and east-facing slopes. Moreover, since this forest is only approximately 40 years old, we can assume that it has not yet reached a stable climax. As the forest continues to mature, we might expect to observe a greater heterogeneity in vegetational composition between the slopes (Odum, 1969). Furthermore, the more mesic north-facing slope might be expected to approach a stable climax more rapidly.

Further evidence for the more favorable micro-climate of the north-facing slope is provided by the differences in basal area observed between the two slopes. Since aerial photography indicates that the majority of the existing forest vegetation dates from the late 1930's and early 1940's, we can assume that these differences are due to faster growth rates on the north-facing slope. However, without a homogeneous species-composition and age-structure between slopes, no definite conclusions can be drawn in regards to absolute growth-rates (Geyer and Naughton, 1970). The fact does remain, however, that the north-facing slope pres-

ently supports a larger basal area per individual.

Micro-climatic differences due to slope-aspect may not be the only environmental factors that have influenced the present vegetation of this ravine. Drought, which occurs in the Great Plains on approximately 20-year cycles, has had a large effect on the vegetation of eastern Kansas and may provide an additional explanation for the restriction of such species as basswood to north-facing slopes. During periods of severe drought, such as that of the 1930's, such species may have been unable to survive on the drier, south-facing slopes (Albertson and Weaver, 1945).

Biological factors such as disease may also have had major effects on the composition of the NESAs forest. Dutch Elm Disease was first diagnosed in Jefferson County in 1961 and it had been reported in neighboring counties as much as three years earlier (Kainski et al., 1964). In the early 1950's, at the University of Kansas Natural History Reservation (located approximately 3 km south of NESAs), $\frac{1}{3}$ to $\frac{1}{2}$ of the trees greater than six inches DBH were elms (Fitch and McGregor, 1956). In contrast, of the 74 trees included in this study only five were elms.

The decline of the American elms was relatively rapid, following the introduction of Dutch Elm Disease to Kansas. Before the advent of the disease, Fitch and McGregor (1956) stated that American elm (*Ulmus americana*) was much more prevalent as a dominant tree than red elm (*Ulmus rubra*), with few red elms being over 12 inches (30.5 cm) DBH, although "the saplings of this species constitute a prominent part of the understory." A comparison between two studies (Wells and Morley, 1964 and unpublished class data, 1975) of Baldwin Woods, 30 km. south of NESAs indicates that by the mid-1960's the population of elms had reached a relatively stable equi-

librium (Table 3). It should be noted that in both studies, the disease resistant red elm is more important, a reversal of the previous observations of Fitch and McGregor (1956). From the above, one can conclude that the elms, particularly the American elm, have been removed as major dominants in the forest canopy within the last 20 years.

Other species may have also been selectively removed from the area by the activities of man. Logging of Jefferson County and nearby Douglas County has been widespread for more than 100 years (Fitch and McGregor, 1956) and there is evidence of logging within the NESAs area. In addition to the observation of several large, sawed stumps, several individuals of red oak and black walnut have multiple trunks emitting from a common root system. As red oak and black walnut are among the species most heavily used by the lumber-industry in Kansas (Deneke and Funsch, 1970), it is likely that the multiple trunks sprouted after logging. Age measurements of one such multiple trunk-system revealed that the ages of the separate trunks were within a range of five years. Other tree-cutting activities, such as the rural practice of heating and cooking with wood, also accounted for a share of the woodland disturbance until about 1940.

Although the sampling methods were not identical, one can compare the results of this study with two others done within a nearby forested area. Both Wells and Morley's (1964) study and unpublished data from a University of Kansas class (1975) involved Baldwin Woods, an unglaciated area 30 km. south of NESAs. The major finding of the 1975 study was that the topographic position on the slope was as important as slope-aspect in determining the composition of the canopy. However, the topographic gradient of Baldwin Woods is much greater than that

of the NESAs ravine (circa 100 meters versus 16 meters). While in both instances the slope-aspect largely determines canopy composition, conclusions relating to the much larger topographic gradient of Baldwin Woods are not directly applicable to the site at NESAs.

A higher species-diversity was also found in the Baldwin Woods studies. While some of this increase could be explained by the greater topographic diversity of Baldwin Woods, the major factor appears to be the greater edaphic diversity there. Baldwin Woods is unglaciated and has a variety of parent materials while the soils of NESAs were formed primarily of colluvium from the limestone-outcrops, with both loess and glacial till being influential. Other than the actual limestone-ledges (Plots 6 and 9), the soils in the study area have formed from virtually identical parent materials.

The overall diversity within the forest canopy can also be shown to be dependent upon a set of limiting factors. In both the NESAs study and Tramer's (1969) study of 267 bird populations, diversity was dependent upon the number of species (species-richness). For the NESAs plots, the population diversity (H') correlated at significant levels ($r = 0.975$ and 0.939) with $\ln S$, the natural logarithm of species-richness. This relationship contrasts with that of phytoplankton in which the species-richness remains stable, and species-diversity is linked to the relative abundance of species (Sager and Hasler, 1969). Certain phytoplankton species are "opportunistic," and may experience dramatic fluctuations in population size in response to changes in availability of resources. Thus, although the number of species in a given area may remain approximately the same over a period of time, estimates of species-diversity will decrease due to changes in relative abundance.

Conversely, Tramer (1969) notes that birds are "equilibrating," since the environmental factors of a given habitat determine the number of species which can exist in that habitat. As species-diversity for the NESA tree-canopy was comparable to Tramer's bird populations in terms of dependence on species-richness, the diversity of the forest-canopy may also be a result of environmental parameters which regulate the number of species that can exist in a given area.

In summary, extensive pressures due to logging, fire, farming practices, Dutch Elm Disease, and periodic droughts have contributed to the present condition of this forest. However, micro-climatic differences in moisture availability are also of great importance. There is an increase in temperature, evapotranspiration, and water stress on the south-facing slope, resulting in a more favorable micro-climate for forest vegetation on the north-facing slope. The more favorable micro-climate is shown by a shift in species composition within the forest-canopy and by larger basal areas per individual for the north-facing slope.

LITERATURE CITED

- ALBERTSON, F. W., AND J. E. WEAVER. 1945. Injury and death or recovery of trees in prairie climate. *Ecol. Mono.* 15: 393-433.
- BENSON, L., E. A. PHILLIPS, P. A. WILDER, ET AL. 1956. Evolutionary sorting of characters in a hybrid swarm. I. Direction of slope. *Amer. J. Bot.* 54(8): 1017-1026.
- BOUGHLEY, A. S. 1973. *Ecology of Populations*, 2nd edition. The Macmillan Company, New York.
- COOPER, A. W. 1960. An example of the role of microclimate in soil genesis. *Soil Sci.* 90:109-120.
- COX, W. G. 1972. *Laboratory Manual of General Ecology*, 2nd edition. Wm. C. Brown Company Publishers, Dubuque, Iowa.
- DENEKE, J. R., AND R. W. FUNSCH. 1970. Early notes on black walnut provenance tests in Kansas. *Trans. Kans. Acad. Sci.* 72:404-405.
- FITCH, H. S., AND R. L. MCGREGOR. 1956. *The Forest Habitat of the University of Kansas Natural History Reservation*. University of Kansas Publications of the Museum of Natural History 10:77-127.
- GEYER, W. A., AND C. G. NAUGHTON. 1970. Growth and management of black walnut (*Juglans nigra* L.) on strip-mined lands in southeastern Kansas. *Trans. Kans. Acad. Sci.* 73:491-502.
- KAINSKI, J. M., E. D. HANSING, W. H. SILL, JR., C. L. KRAMER, AND O. J. DICKERSON. 1964. Kansas phytopathological notes: 1961. *Trans. Kans. Acad. Sci.* 67:433-441.
- KORMONDY, E. J. 1969. *Concepts of Ecology*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.
- LITTLE, E. L. 1971. *Atlas of U.S. Trees Vol. 1: Conifers and Important Hardwoods*. U.S. Dept. Agric. Misc. Publ. 1146.
- ODUM, E. 1969. The strategy of ecosystem development. *Science* 164:262-270.
- SAGER, P. E., AND A. D. HASLER. 1969. Species diversity in lacustrine phytoplankton. I. The components of the index of diversity from Shannon's formula. *Amer. Natur.* 103:51-60.
- TRAMER, E. J. 1969. Bird species diversity: components of Shannon's formula. *Ecology* 50:927-929.
- U.S.D.A. 1977. Preliminary soil survey for parts of Jefferson County, Kansas. U.S. Dept. Agric.
- WEAVER, J. E., H. C. HANSON, AND J. M. AIKMAN. 1925. Transect method of studying woodland vegetation along streams. *Bot. Gaz.* 80:168-187.
- WELLS, P. V., AND G. E. MORLEY. 1964. Composition of Baldwin Woods: an oak-history forest in eastern Kansas. *Trans. Kans. Acad. Sci.* 67:65-69.

TABLE 1.

A listing of the eleven tree species appearing in the NESA study plots in order of decreasing Importance-Values. The effect of slope-aspect on numbers, frequency, density, dominance and importance is also given.

	#	RELATIVE	RELATIVE	RELATIVE	IMPORTANCE	AVERAGE
	INDIVIDUALS	FREQUENCY	DENSITY	DOMINANCE	VALUE	IMPORTANCE
						VALUE
RED OAK						
North-facing	4	17.6	13.3	25.0	55.9	59.6
South-facing	6	17.6	15.4	30.3	63.3	
BLACK WALNUT						
North-facing	6	17.6	20.0	33.0	70.6	53.2
South-facing	3	11.8	7.7	16.2	35.7	
WHITE ASH						
North-facing	3	11.8	10.0	1.8	23.6	44.3
South-facing	11	17.6	28.2	19.2	65.0	
SHAGBARK HICKORY						
North-facing	3	11.8	10.0	3.6	25.6	34.5
South-facing	9	11.8	23.1	8.5	43.4	
RED ELM						
North-facing	1	5.9	3.3	10.0	19.2	25.1
South-facing	4	11.8	12.8	6.3	30.9	
BUR OAK						
North-facing	4	5.9	13.3	11.2	30.4	25.0
South-facing	1	5.9	2.6	11.1	19.6	
BASSWOOD						
North-facing	6	17.6	20.0	9.2	46.8	23.4
South-facing	0	0.0	0.0	0.0	0.0	
CHESTNUT OAK						
North-facing	2	5.9	6.7	5.2	17.8	19.4
South-facing	2	11.8	5.1	4.2	21.1	
BLACK OAK						
North-facing	0	0.0	0.0	0.0	0.0	6.0
South-facing	2	5.9	2.6	3.4	11.9	
RED BUD						
North-facing	1	5.9	3.3	0.9	10.1	5.0
South-facing	0	0.0	0.0	0.0	0.0	
HACKBERRY						
North-facing	0	0.0	0.0	0.0	0.0	4.6
South-facing	1	5.9	2.6	0.8	9.3	

TABLE 2.
Basal area for each sample plot and average basal area per individual.

PLOT	ASPECT OF SLOPE	NUMBER OF INDIVIDUALS PER PLOT	BASAL AREA PER PLOT (SQ. IN./100M ²)	BITTERLICH BASAL AREA MEASUREMENT (SQ. IN./100M ²)	BASAL AREA PER TREE (SQ. IN.) (S.D.)
1	North	4	203.29	263.41	50.82 ± 39.12
2	South	8	221.62	312.19	27.70 ± 11.55
3	North	8	216.94	282.92	27.12 ± 4.94
5	South	12	258.58	243.90	21.55 ± 4.13
7	North	10	323.01	292.88	32.20 ± 6.69
8	South	10	257.35	253.66	25.72 ± 4.40
6*	North	8	866.58	390.24	108.32 ± 34.36
9*	South	9	746.64	409.75	82.96 ± 26.14
4**	Neither	5	284.70	243.90	56.94 ± 23.64
All North Mean (Plots 1, 3, 6 and 7)		7.50 (±2.52)	402.46 (±314.01)	307.36 (±56.39)	53.70 (±65.38)
All South Mean (Plots 2, 5, 8 and 9)		9.75 (±3.37)	371.05 (±250.98)	304.88 (±76.14)	38.08 (±47.15)
Overall Means (Plots 1-9)		8.24 (±2.49)	375.41 (±249.00)	299.21 (±61.70)	45.68 (±55.71)

* Plots 6 and 9 are located on rocky outcrops.

** Plot 4 is on a level area adjacent to a south-facing slope.

TABLE 3.

Comparison of the importance of elm species in three studies located in eastern Kansas. The 1956 study was before the introduction of Dutch Elm Disease.

		1956 ³ Nat. Hist. Res.	1964 ⁴ Baldwin Woods	1975 ⁵ Baldwin Woods
Red Elm (<i>Ulmus rubra</i>)	I.V. ¹ Freq. ²	*	18.3 8.7	22.0 6.4
American Elm (<i>Ulmus americana</i>)	I.V. ¹ Freq. ²	*	2.5 0.8	3.0 1.1
<i>Ulmus spp.</i> (9 total)	I.V. ¹ Freq. ²	*	*	*
		25.8 ⁶ to 57.9 ⁷	9.5	7.5

¹Importance Value; ²Frequency (in percent); ³Fitch and McGregor, 1956; ⁴Wells and Morley, 1964; ⁵Unpublished class data, University of Kansas; ⁶For trees greater than one foot DBH on a West Slope; ⁷For trees six inches to one foot DBH on a South slope; * Not listed.