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A STUDY OF THE ENVIRONMENT AND FLORISTIC COMPOSITION OF AN OAK-HICKORY WOODLAND IN NORTHEASTERN OKLAHOMA

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This study was undertaken for the purpose of obtaining detailed information of a plant community typical of part of Oklahoma. The area selected is situated five miles south of Tulsa on eroded sandstone hills

near the ecotone between the oak-hickory savannah to the west and the prairie to the east, as mapped by Bruner[1]. A portion of this oak-hickory savannah woodland, covering 400 acres, is less disturbed than any similar area in the region and is considered to be in good natural condition.

ENVIRONMENTAL MEASUREMENTS

Field work was carried out during the three spring months of March, April and May of 1937. Environmental measurements included those of precipitation, evaporation and soil moisture. By means of a rain gauge, a total of 3.8 inches of rainfall was obtained for the 55 day period between April 10 and June 1. A comparison with official weather records in Tulsa and with an official weather station maintained at Broken Arrow, 8 miles east of this area, for the 52 years prior to 1930[2], indicates that the precipitation for the three months of 1937 was about two-thirds of the average for that period, and also that the number of rainy days was 22 per cent below the average. A further reference to these same sources indicates that both maximum and minimum temperatures during the period of study were slightly higher than the average, except in March.

Measurements of the evaporating power of the air were made with Livingston's standardized porous bulb otmometers, using a white bulb at each of two stations and for comparison one black bulb at Station 2. The atmometers were set out early in April after freezing weather was over. The reading of the three atmometers, when plotted graphically, gave lines which corresponded inversely, in a rough way, to the precipitation curve. The highest evaporation percentages came late in April and in the middle of May during periods of low rainfall. The highest reading was a loss on April 24 by the black bulb of 1.62 c. c. per hour, the corresponding white bulb losing 1.38 c. c. per hour, the difference between the two being the evaporation due to solar heat absorbed by the black surface.

The soil covering these sandstone hills is shallow, averaging about 1 foot in depth. Only two layers are evident, the 2-inch humus layer, quite sandy, and the remaining material consisting of sand and grading into fragments of sandstone. In one area yellow clay was found below the sand, and also sandstone fragments. Soil moisture determinations were made 22 times during the period between March 9 and May 25, at two stations, one in sand on a northeast slope bearing oak and hickory and the other where clay was present on a south slope bearing oak. A graphic analysis of the soil moisture determinations taken at depths of 0-2 inches and 10-12 inches showed a good correspondence between the two stations, the maximima and minima occurring on the same days. A close correlation was noted between high soil moisture values and periods of high precipitation. The highest values were 27 and 25 per cent at the 0-2 inch level of Stations 1 and 2 on April 22 and 24, thus corresponding with the highest rainfall of 1.75 inches on April 22. In the sandy station the consistently lower values at the 10-12 inch depth indicated the poor water-retaining capacity of this soil. The same conclusion may be reached from the values of April 17 when both depths in the sandy station and the upper level of the clay station all dropped to 8 and 9 per cent, but the lower level of the clay station retained its moisture of 18 per cent.

FLORISTIC COMPOSITION

In studying the floristic composition of the savannah woodland, greater emphasis was placed on the dominant woody vegetation than on the herbaceous undergrowth. Work over the 400 acres resulted in dividing the area into three parts: the oak-hickory community on the hillsides, the elm-ash-oak community of the stream beds and the prairie-edge type

of woodland, or ecotone, on the hilltops. The greater part of the work was done in the typical oak-hickory community, using the other groups for comparison.

WOODY VEGETATION

The woodland which covers the sandstone slopes is somewhat open in character, with the trees in groups or with single trees spaced 10 to 15 feet apart. The post oak, *Quercus stellata* Wang., appears to dominate the others from the standpoint of size and forms a first layer which in some places overspreads the black jack oak, *Q. marilandica* Muench., and the hickory, *Carya buckleyi* Dur. Some difference was noted in the degree of xerophytism of the different slopes, as evidenced by the greater number of black jacks on south-facing slopes, but for the most part the slopes were not steep enough to cause great variations.

The method of field analysis was the belt transect. Twelve transects, 3 feet wide, and the majority 600 feet long, were laid out on the hillsides. The diameter breast high (D. B. H.) of each specimen was measured by an accurate pair of tree calipers. By using the formula for the area a circle (πr^2) the area of a horizontal plane passing through the trunk was then obtained and denoted as the cross-section area.

The results of the 12 transects are first presented, in Table I, in terms of the per cent of the area occupied by the major trees. These figures

TABLE I. *Per cent of area occupied by principal trees of the oak-hickory community.*

Transect			Percent of Area Occupied		
No.	Length in ft.	Slope Face	Post Oak	Black Jack Oak	Hickory
1	819	n. e.	.215	.520	2.000
2	500	s. w.	1.060	.170	.140
3	400	n.	.270	——	.720
4	500	s. w.	2.970	——	.567
5	600	s. w.	2.820	1.157	——
6	600	s.	2.140	.449	.193
7	600	n. e.	4.530	1.120	——
8	600	n. e.	.760	1.600	——
9	600	s. e.	1.117	1.127	——
10	600	n.	1.590	——	1.300
11	600	w.	.360	.057	2.240
12	600	s. e.	1.127	.115	.237
Total	7019		19.077	6.331	7.416

were obtained by relating the cross-section area of each species to the area of the transect in terms of per cent of occupation. The total area of the 12 transects was 21,057 square feet. In Table I it will be seen that two species were sometimes equally dominant, as in transect 9, but more often one species outranked the others in per cent occupation. In the totals for the 12 transects it will be noted that the post oak occupied by far the greatest percentage of the area as a whole, with the black jack and the hickory occupying about one-third as much. There is also evident in Table I an inverse relationship between the two oaks and the hickory. The largest percentages of hickory occurred in transects 1, 10 and 11, and were accompanied by small percentages of oaks. Transects 5 and 7, on the other hand, had the largest percentages of oaks and no hickory

at all. It is impossible to say whether this relationship would be substantiated by still more extensive sampling in this and other areas, or to advance a reason for its existence.

The results of the 12 transects are next presented, in Table II, in terms of size class occurrence. In this method, used by Lutz in 1930[3], the

TABLE II. *Size class occurrence of principal trees of the oak-hickory community.*

Transect	Size Class Occurrence																	
	Post Oak						Black Jack Oak						Hickory					
No.	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
1	28	18	1	..	1	..	15	3	5	3	1	..	12	18	10	6	..	..
2	7	4	1	2	1	1	16	..	1	..	2	..	..	2	6	..	..	..
3	..	1	..	..	2	..	6	..	..	..	..	..	..	4	1	3	1	..
4	57	11	..	1	5	..	2	1	..	..	..	..	14	9	4	3	..	..
5	44	26	17	3	1	..	32	5	4	6	..	..	1	..	..	..	..	..
6	50	15	6	1	2	1	20	3	3	4	..	..	20	11	4	..	..	..
7	32	26	7	1	3	1	18	8	4	4	1	..	1	..	..	..	..	..
8	22	..	1	2	1	1	17	1	1	6	2	..	5	..	..	..	..	..
9	92	6	1	2	2	1	33	5	2	4	1	..	15	..	..	..	..	..
10	60	10	1	..	4	..	19	1	..	..	..	..	15	12	9	2	1	..
11	33	5	5	2	..	..	21	1	1	..	1	..	11	16	1	10	1	..
12	31	4	8	1	..	1	17	4	2	1	..	..	14	2	2	1	1	..
Total	456	126	48	15	22	6	216	32	23	28	8	..	108	64	37	25	4	..

following arbitrary size classes are set up according to trunk diameters (D. B. H.): class 1, 0-.5 inches; class 2, .5-2 inches; class 3, 2-5 inches; class 4, 5-10 inches; class 5, 10-18 inches and class 6, 18 inches and above. Specimens falling in class 1 are considered as reproduction. The trees ecologically dominating the community are those which fall in classes 5 and 6. Table II indicates first that the post oak leads the others in number of individuals. Of greater interest, however, is the distribution of individuals in the size classes, which quickly shows the superiority of the post oak. In classes 5 and 6, denoted as containing the only true dominants, the transect totals were 28 post oaks, 8 black jack oaks and 4 hickories. Bruner's statement[1] that in mixtures of post oak and black jack the two dominants attain approximately the same size cannot hold in this case. It will be noted that the post oak alone had specimens in size class 6, meaning a D. B. H. of 18 inches or more, and that the largest black jack measured 16 inches. The size dominance of the post oak, moreover, is evident upon entering the woodland.

There exists in this community considerable variability in species and in individuals. This is partly due to dense stands of reproduction which occur in open areas, with no species dominant in forming them. The oldest oaks have only a moderate crown spread and do not directly dominate much space, with the result that several age groups occupy an area. Small grassy openings are not uncommon, as in any savannah woodland, and the extent of their permanency is not known.

Specific examples of variability of species and individuals may be seen in the results of certain transects. In transect 7, for example, there was a distinct change in dominant species, beginning with a few large post oaks and hickories, going through a reproduction area populated principally by post oaks, passing two very large and some smaller post oaks, and finally ending with a space dominated by good-sized black jacks, all

of this change in species and in numbers of individuals occurring within the 3-foot wide belt which was 300 feet long.

A comparison of the principal tree species is made in Table III. The post oak is given a frequency of 100 per cent because it occurred in

TABLE III. *Comparison of principal trees of the oak-hickory community.*

Species	Frequency	Dominance	Water Relations	Reproduction
Post Oak	100.0%	70%	Mesic	2.00 : 1
Black Jack Oak	66.6%	20%	Xeric	2.36 : 1
Hickory	Varies	10%	Mesic	.83 : 1

every sample. By adopting .1 per cent area occupied as the minimum for a record of occurrence, the frequency of the black jack can be set at 66 2/3 per cent. Dominance of post oak is set at 70 per cent by noting that 28 of all the trees in classes 5 and 6 were post oaks. The application of the relative term xeric to the black jack oak came from observations of its frequency in the drier situations. The reproduction estimate of 2 : 1 indicates that there were twice as many post oaks in class 1 as in the sum of the other five classes. The table serves to bring out again the importance in this community of the post oak and the relative positions of the other species. The reproduction figures indicate that a somewhat similar relationship is likely to be maintained in the near future.

Having disposed of the three dominant trees, it remains to consider the other species which make up the oak-hickory community on the hillsides. Two trees occur here in sufficient numbers to warrant the title of subdominants, the winged elm, *Ulmus alata* Michx. and the white ash, *Fraxinus americana* L. In addition to some larger trees, each of these species is represented by a great abundance of reproduction. A total of 111 white ash of class 1 was noted in the 12 transects as compared with 23 in all other classes, but since 12 of the latter were in class 4 and 2 were in class 5, there is an indication of a greater importance for the white ash in the future. The occurrence of such an abundance of winged elm on the oak-hickory slopes may be somewhat unusual. Bruner[1] mentions this species only in connection with flood plains. The increase, both in size and numbers, of this tree in the stream-side community will be noted later, but its presence on the drier slopes under the oaks and hickories should not be overlooked. The total number of individuals in the 12 transects was 506; 470 of these being in class 1, 22 in class 2, 9 in class 3 and 5 in class 4. The winged elm is present on the hillsides, then, as a very noticeable understory and, since there is less water available here than near the stream beds, it will probably remain as small trees instead of assuming a position of dominance in the oak-hickory community.

The following minor tree species were noted to accompany the oaks and hickory on the slopes: black oak, *Q. velutina* Lam., chinquapin oak, *Q. Muhlenbergii Engelm.*, American elm, *U. americana* L., red haw, *Crataegus* sp.,* wild plum, *Prunus* sp., black walnut, *Juglans nigra* L., red bud, *Cercis candanesis* L., arrow wood, *Viburnum rufidulum* Raf.,* false buckthorn, *Bumelia lanuginosa* (Michx.) Pers. mulberry, *Morus rubra* L., bitternut hickory, *C. cordiformis* (Wang.) K. Koch. Some additional

*Identified by Milton Hopkins, Univ. of Okla.

species of shrubby oaks were present but no attempt was made to identify them.

The following list of shrubs completes the woody undergrowth on the hillsides: coral-berry, *Symphoricarpos orbiculatus* Muench., small-flowered dogwood, *Cornus asperifolia* Michx., several sumacs, *Rhus glabra* L., *R. copallina L., R. toxicodendron* L., *R.canadensis* Marsh., wild rose, *Rosa* sp., wild grape, *Vitis* sp., blackberry, *Rubus frondosus* Bigel.,* and greenbrier, *Smilax* sp. Of these, coral-berry is by far the most abundant. No particular relationship has been noted in the distribution of this shrub with habitat variation or with other species.

In studying the portion of the woodland previously noted as the elm-ash-oak community, a belt transect 900 feet long was run in the bed of the largest drainage course. The stream bed was old enough for the early flood plain stages to have disappeared. The transect was not run at random in this case, but directed so as to include the different species present. It has therefore greater significance from a qualitative than from a quanitative standpoint. The importance of the winged elm in this wetter location is indicated by its occupation of 1.66 per cent of the area, as compared with .31 per cent for the post oak, .44 per cent for the hickory, and .93 for the white ash. Here the winged elm reaches a greater size, 3 individuals being in class4 and 4 in class 5. The winged elm is a dominant, then, in this stream-side community which is a seral stage within the area of the oak-hickory woodland. The other trees large enough to be true dominants are white ash, post oaks and chinquapin oaks, one specimen of the latter measuring 30 inches D. B. H. Trees peculiar to this community are the hackberry, *Celtis occidentalis* L., pecan, *Carya pecan* Engler and Gr., willow, *Salix nigra* Marsh. and Kentucky coffee-tree, *Gymnocladus dioica* (L.) Koch. A few trees found on the hillsides were also noted here, as false buckthorn, arrow wood, mulberry and bitternut hickory. Mention should also be made of the importance in this community of the white ash and of the complete lack of black jack oak. As this sere reaches later stages of development and becomes progressively drier, the floristic composition will be more nearly like that of the hillsides.

The prairie-woodland ecotone occurring along the top of the highest ridge is an interesting phase of the oak-hickory community. The ridge-top is flat with outcropping sandstone and supports grassy openings which merge to the east into the rolling prairie. It would appear that the prairie is gradually encroaching on the woodland on this ridge-top. Dead trees along the edge of the woodland and in oak islands surrounded by prairie indicate the severity of the last years of drought.

Three belt transects run from woodland across prairie openings and oak islands served to bring out a few facts regarding the ecotone. The trees at the edge of the woodland are for the most part small in size, but exceptions do exist, as 2 hickories, 10 inches D. B. H., occurring 125 feet from the prairie opening. Black jack oaks are especially abundant in the ecotone and most often form the actual border of the grassy opening. The persimmon, *Diospyros virginiana* L., which occurs in some places here, has suffered considerable mortality in past years. The oak islands which apparently exist as remnants have both black jack and post oaks. Coral-berry occurs at the edge of the woods and throughout the oak islands.

HERBACEOUS VEGETATION

In studying the herbaceous vegetation of this example of oak-hickory woodland, collections were made of all plants considered important. Those

*Identified by Milton Hopkins, Univ. of Okla.

not blooming were transplanted into pots until mature and then identified and pressed. The following list of the 16 species considered the most prominent on the woodland floor is given in the order of their appearance and states the duration of the blooming period:

Draba caroliniana	Mar. 10 - Apr. 6
Houstonia minima	Mar. 10 - Apr. 12
Claytonia virginica	Mar. 10 - Apr. 26
Erythronium mesochoreum	Mar. 13 - Mar. 20
Cardamine parviflora	Apr. 3 - Apr. 6
Selenia aurea	Apr. 3 - Apr. 22
Viola Rafinesquii	Apr. 3 - Apr. 25
Collinsia violacea	Apr. 6 - May 15
Oxalis violacea	Apr. 22 - May 15
Linaria canadensis	Apr. 29 - May 15
Silene antirrhina	Apr. 29 - May 15
Specularia leptocarpa	Apr. 29 - June 1*
Valerianella stenocarpa	May 6 - May 13
Oenothera linifolia	May 13 - May 27
Spermolepis divaricata	May 15 - June 1*
Geranium carolinianum	May 25 - June 1*

*Still blooming at conclusion of field work on June 1.

The change from prevernal to vernal society was established by the first of May. During that month plants still bloomed in the more open spaces between the trees but in the deeper shade grasses and plantains replaced the earlier flowers. By the first of June the vegetation was again different due to the importance of such plants as *Pentstemon, Erigeron, Delphinium* and *Rudbeckia.*

The following list includes all herbaceous species identified from the woodland. No attempt was made to cover the plants of the prairie opening along the ecotone.

* *Allium arenicola* Small
* *Antennaria plantaginifolia* (L.) Richards
* *Bellis integrifolia* Michx.
* *Cardamine parviflora* L. var. *arenicola* (Brit) Schultz
* *Carex pennsylvanica* Lam.
* *Chaerophyllum procumbens* (L.) Crantz
* *Claytonia virginica* L.
* *Collinsia violacea* Nutt.
* *Delphinium Penardi* Huth
* *Draba caroliniana* Walt.
* *Draba cuneifolia* Nutt.
* *Erigeron ramosus* (Walt.) BSP.
* *Euphorbia arkansana* Engelm and Gray
* *Festuca octoflora* Walt.
Geranium carolinianum L.
* *Houstonia minima* Beck
* *Hypoxis hirsuta* (L.) Coville
Linaria canadensis (L.) Dumont.
* *Lithospermum angustifolium* Michx.
* *Myosotis virginica* (L.) BSP.
* *Nothoscordum bivalve* (L.) Britton
* *Oenothera laciniata* Hill
Oenothera linifolia Nutt.
Oxalis stricta L.
Oxalis violacea L.

* *Panicum Scribnerianum* Nash
* *Pentstemon acuminatus* Dougl.
* *Phacelia dubia* (L.) Small
* *Ranunsulus abortivus* L.
* *Rudbeckia hirta* L.
  Selenia aurea Nutt.
* *Senecio obovatus* Muhl.
  Serinia oppositifolia (Raf.) Ktze.
* *Silene antirrhina* L.
  Specularia leptocarpa (Nutt.) Gray
* *Spermolepis divaricata* (Walt.) Britton
* *Valerianella stenocarpa* (Engelm.) Krock.
* *Viola missouriensis* Greene
* *Viola Rafinesquii* Greene

*Indentified by Milton Hopkins, University of Oklahoma.

SUMMARY

An oak-hickory woodland, covering 400 acres on sandstone hills near Tulsa, was selected as a typical example of the savannah woodland of Oklahoma. Environmental measurements made during three spring months of 1937 include those of precipitation, evaporation and soil moisture. The woodland soil is shallow and consists of sand with little humus and with occasional areas of clay.

The woodland is composed of the typical oak-hickory community on the hillsides, an elm-ash-oak seral community in the stream beds and the prairie-edge type of woodland on the hill-tops. In the oak-hickory community statistics obtained from 12 belt transects show that the post oak, black jack oak and hickory are all true dominants. The post oak shows three times as much per cent of area occupied as the other two, and also outranks the others in size and in numbers of true dominants. The community exhibits variability both in species and in numbers of individuals. There is an indication that three present dominants will retain the same relationship. Of two subdominants, the white ash and the winged elm, the former may be of more importance in the future, but the winged elm, although present in great numbers, is likely to remain as a low understory. Eleven tree species and ten shrubs comprise the remainder of the woody vegetation of the hillsides.

The stream-side seral community is dominated by winged elm, white ash, post oak and chinquapin oak. Four additional tree species were found here which were also on the hillsides, and four species which were peculiar to this habitat. This community will become more like the hillsides in floristic composition as it attains greater maturity.

The ridge-tops form the ecotone between prairie and woodland, with the woodland the loser at least in recent years. Oak islands exist as apparent remnants.

A list of 16 herbs considered most prominent on the woodland floor is given in order of their appearance and with the duration of their blooming dates. Both May 1 and June 1 were seasonal landmarks in the development of herbaceous undergrowth. In all, 39 species of herbs, including 1 sedge, and 2 grasses, were identified from this oak-hickory woodland.

LITERATURE CITED

1. Bruner, W. E. 1931. The Vegetation of Oklahoma. Ecological Monographs 1: 99-188.

2. Martin, R. J. and J. B. Kincer. 1931. *Climatic Summary of the United States. Section 43, Eastern Oklahoma. United States Department of Agriculture Weather Bureau.*

3. Lutz, H. J. 1930. The Vegetation of Heart's Content, a Virgin Forest in Northwestern Pennsylvania. Ecology 11: 1-29.