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RELATIONSHIPS OF THE WOODY VEGETATION OF THE WICHITA MOUNTAINS WILDLIFE REFUGE TO GEOLOGIC FORMATIONS AND SOIL TYPES

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RELATIONSHIPS OF THE WOODY VEGETATION OF THE WICHITA MOUNTAINS WILDLIFE REFUGE TO GEOLOGIC FORMATIONS AND SOIL TYPES

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INTRODUCTION

Only passing references are available in the literature concerning the effect of either geologic formations or soil types on vegetational associations in the state of Oklahoma (Bruner 1931, Luckhardt and Barclay 1938, Blair and Hubbell 1939, Duck and Fletcher 1945). The literature contains few reports of work of this nature in areas outside of the state (Cuyler 1931, Diebold 1935, Dyksterhuis 1948, Salisbury 1954). The two factors are seldom considered together (Beilmann and Brenner 1951).

This work was concerned with possible relationships between the woody vegetation of the Wichita Mountains Wildlife Refuge and the geologic formations and soil types. To discover any such correlations both quantitative and qualitative analyses of the vegetation were necessary. Bruner

(1931), Blair and Hubbell (1939), and Rice and Penfound (1959) all reported briefly on the woody vegetation in the area of the Wildlife Refuge but no detailed phytosociological studies were carried out.

DESCRIPTION OF AREA

The Wichita Mountains Wildlife Refuge, composed of 59,099 acres, is located entirely within Comanche County in southwestern Oklahoma. The refuge, established in 1901 as a forest reserve was transferred in 1935 from the United States Forest Service to the United States Fish and Wildlife Service under the auspices of the Department of the Interior (Dana 1956). It has been protected from fire since its inception and from grazing by domestic cattle since 1937. Since the removal of domestic animals it has functioned as a big game refuge and has been subjected to the grazing and browsing pressures of a controlled population of antelope, buffalo, deer, elk, and longhorn cattle (Halloran and Glass 1959).

The Wichita Mountain System is approximately 60 miles long and 25 miles wide and the general trend of the mountains is N. 70° W. The portion of the system encompassed by the refuge is chiefly igneous material, but with limited patches of Permian Red Beds, and recent alluvium (Snider 1917 and Anderson 1946). The mountains are monadnocks, the igneous roots of an earlier mountain system which at one time was covered by an estimated 11,000 feet of sedimentary material which has since eroded away (Gould 1911).

The igneous rocks of the refuge are late Pre-Cambrian and are chiefly gabbro and granite (Chase et al. 1956). An estimated three per cent of the area is composed of gabbro, a dark gray to black, medium to coarse grained, igneous rock. These rocks weather into gentle slopes with only an occasional low ridge. The granite has been separated into three types; Carlton, Quanah, and Lugert (Chase, no date). Schoonover (1948) and Ham et al. (1957) have indicated that the Lugert granite of the refuge area of the Wichita Mountain System is unlike that originally reported near Lugert, Oklahoma. Merritt (1962), concurring, suggests that in the near future this formation may be called "Mount Scott" granite.

The Carlton granite is limited to less than two per cent of the refuge and does not support trees. Quanah, which covers about 14 per cent of the refuge, is a coarse grained, light pink rock which is younger than the Lugert material (Hoffman 1930). The latter, a medium grained pink granite, constitutes approximately 58 per cent of the area.

During Permian time both gabbroic and granitic rocks were eroded into large boulder fans (Chase 1954). This material is present today as a coarse bed of conglomerate containing unconsolidated round boulders. It has been named Post Oak Conglomerate. Except for a small area of gabbroic derived rock, this formation, which covers about 17 per cent of the refuge, is derived from granite. The alluvial areas cover nearly 36 per cent of the refuge and are composed of the products of disintegration and decomposition of the rocks which have washed into the lower areas. The soils in these regions range from dense, tight soils to coarse, loose ones.

Schoonover (1948) reports four sets of major vertical joints in the rocks of the Wichita Mountain System. These joints, an outcome of rock emplacement during orogenic activity, have resulted in variations in the rate of rock decomposition and water availability and consequently have an important bearing on vegetational distribution (Fig. 1).

An increase in elevation takes place from the eastern edge of the refuge to the west. The highest elevation is Mount Pinchot, 2,479 feet. However, the greatest relief is found at Mount Scott where the 2,464 foot peak is approximately 1,200 feet above the surrounding plain.

The granitic mountains are relatively high jagged peaks of bare rock. The upper slopes are strewn with large talus boulders and covered with little soil. The steep, even slopes of the mountains below the rock peaks are covered with a coarse soil trapped between large rocks. Many trees are found on these slopes. Some of the intermediate hills have flattened tops covered with a shallow layer of soil which supports herbaceous vegetation. The almost continuous mountains are bisected by wide grassy valleys filled with deep soils.

The vegetation of the refuge was reported by Duck and Fletcher (1945) as a combination post oak - blackjack oak forest and mixed grass eroded plains type. Blair and Hubbell (1939) reported the grasslands to be suggestive of the tall grass of the Cherokee Prairie in northeastern Oklahoma. They stated also that the dry oak forests closely parallel in character the xeric forests of the sandstone ridges of the Osage Savanna district.

The most common forest association in the refuge is that of post oak - blackjack oak. However, along the streams in the protected valleys and on the north facing slopes a more mesic forest type is encountered. Common in these areas are Shumard oak (Quercus shumardii*), bur oak (Q. macrocarpa), chinquapin oak (Q. muhlenbergii), American elm (Ulmus

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*The botanical nomenclature follows Waterfall (1960). Varietal epithets were arbitrarily omitted.

americana), western walnut (Juglans rupestris), chittamwood (Bumelia lanuginosa), and other species which often have eastern affinities. The grasses are also variable with areas representative of tall, mixed, and short grass prairies.

The Comanche County Unit of the Soil Conservation Service has recently finished a complete soil mapping of the refuge. Eleven soil types were mapped during this work and four of these support enough trees to be considered forests or woodlands. Brief descriptions of the four types follow. In future references to these soil types only the numerical symbols will be utilized.

Lawton loam, Type 6. This is a deep (26 - 44 in.) soil, noncalcareous, acidic (pH 6.5 to 6.0), and ranging from a fine sandy loam to silt loam at the surface to a relatively unweathered soil material below 40 in. The 'A' horizon ranges from 9 to 15 inches, and surface drainage is good whereas internal drainage is slow.

Cobbly colluvial, Type 7. This soil type is intermediate in depth (12 - 20 in.), noncalcareous, neutral in pH, moderately granular at the surface, and grading to finer granitic pebbles at lower levels. The 'A' horizon ranges from 4 to 6 inches, and the surface drainage is moderate to rapid while the internal drainage is moderate. From 20 to

60 per cent of this type is composed of weathered cobbles and boulders of gabbro and granite (Fig. 2).

Rough stony land, Type 27s. This type is composed of scattered pockets of skeletal soil between boulders which comprise the rough areas of outcropping granite. It is variable in depth, is generally coarse, has no profile development, and drainage is rapid. Many seeps from the granitic masses are present.

Loamy drainageways, Type 31r. These consist of undifferentiated alluvial soils which have been massed in the drainageways. The soil depth and texture are variable due to active erosion and deposition. For the same reason there has been no profile development. This type supports typical bottomland vegetation.

The climate of southwestern Oklahoma is typically continental. Temperatures for January average 38.3 F and for July 81.3 F (20 year record). In the same period temperatures as high as 112 F and as low as -16 F were recorded (U.S.D.A. Yearbook, 1941). A 32 year record of early and late killing frosts indicates a growing season of 203 days (ibid.). The mean annual precipitation is 30.72 inches (57 year record) (Wichita Mountains Wildlife Refuge Records, 1961). Precipitation is greatest in the spring with a

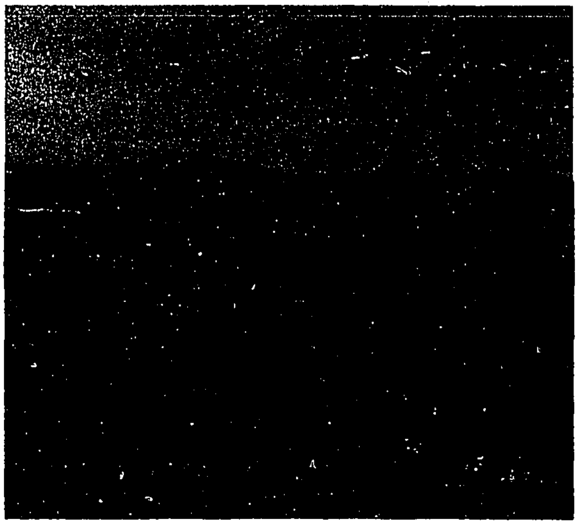

Fig. 1. Bands of woody vegetation following joints in rocks.

Fig. 2. Roadcut on refuge exposing boulders of cobbly colluvial soil type. An almost pure stand of scrubby blackjack oak may be seen in the background.

secondary peak in the fall. Prevailing winds are southerly; however, northerly winds predominate during December, January, and February.

METHODS

The forest areas of the refuge were located with an aerial photograph mosaic on which the soil types were outlined. After subsequent examinations of these woody areas by reconnaissance, 52 stands were selected representing different soil types, slope exposures, and geologic formations. It was clear in each case that the dominant vegetation was woody. No stands were selected which were predominantly grassland with widely scattered trees. Care was taken to select stands which had not been disturbed excessively. Each was examined for evidence of cutting, a perusal of the refuge fire records was made, and the Forest Service's complete planting program was examined. Areas subjected to severe visitor or military use were also omitted. Chase's (no date) geologic map was consulted to assure stands representative of each geologic formation.

Analyses of the woody vegetation were carried out by an augmented variable-radius method. Basal area was obtained by utilizing an angle gauge at 40 evenly spaced but randomly located points in each stand (Rice and Penfound 1955). Several small stands were sampled with fewer than 40 points. The basal area data were supplemented by 40 arms length rectangles of 0.01 acre each which provided frequency and density data in addition to information on reproduction based on numbers of saplings. Any woody plant with a DBH (diameter breast high) of 1.0 to 2.9 in. was classed as a sapling whereas those with a DBH of 3 in. or more were considered trees.

Basal area and relative composition of the herbaceous vegetation and tree seedlings were determined by use of the point quadrat method (Oosting 1956). A thousand points were taken in each stand utilizing a point frame. Notes were made concerning herbaceous species not hit with the point frame or exceptionally common in the area. Density was not determined for these forms.

Forms were prepared allowing consolidation of such field data as the number of saplings and trees, frequency of trees, and basal area of trees in each stand. These data were then converted to the number of saplings and trees per acre, basal area per acre, relative density, relative frequency, relative basal area, and the importance value. The importance value is the sum of the relative frequency, relative density, and relative basal area (Curtis and McIntosh 1951). This value is a good indicator of the relative ecological significance of each tree species in each stand. Species having an importance value of 75 or more were considered dominants.

Differences between the mean values were tested for significance with Student's t-Test as outlined by Snedecor (1956). Standard errors were computed and reported, where applicable, in the tables.

RESULTS AND DISCUSSION

Vegetational Analyses

Of the 24 arborescent species encountered during this investigation the ten most important were analyzed statistically. The selection was made on the basis of mean importance values for all 52 stands. In each of the four soil types and five geologic formations supporting forests and woodlands, post oak (Quercus stellata) was the most important species. Its overall importance can be seen by comparing all mean importance values (Tables I and XIX). Blackjack oak (Quercus marilandica) and eastern red cedar (Juniperus virginiana) were the second and third most important species respectively. The statistically significant differences in density and basal area of species between different soil types are shown in Tables VI - XVIII. Species for which no statistically significant differences were found were not tabulated. Significant differences in species due to geologic formations are presented in Tables XXIII - XXX.

TABLE I. Mean importance value of woody species according to soil types.

Species	6	7	27s	31r
Quercus stellata	193.4	198.2	171.4	127.2
Quercus marilandica	61.6	77.9	69.4	26.2
Juniperus virginiana	26.0	17.5	18.1	18.5
Juglans rupestris	5.5	1.8	2.2	39.2
Celtis reticulata	4.3	1.7	1.0	7.1
Bumelia lanuginosa	2.5	0.7	1.3	11.3
Morus rubra	2.2	- -	0.3	1.7
Prunus mexicana	1.8	0.02	2.8	2.0
Cercis canadensis	1.7	- -	- -	0.1
Ulmus americana	0.6	0.9	1.5	16.2
Fraxinus americana	0.6	- -	0.1	3.6
Ulmus rubra	0.2	- -	- -	- -
Quercus muhlenbergii	0.1	- -	4.1	15.7
Acer saccharum	- -	- -	20.3	0.3
Quercus shumardii	- -	- -	1.0	7.5
Sapindus drummondii	- -	- -	0.3	0.6
Carya illinoensis	- -	- -	- -	7.6
Diospyros virginiana	- -	- -	- -	4.6
Quercus macrocarpa	- -	- -	- -	1.0
Populus deltoides	- -	- -	- -	0.2
Crataegus sp.	- -	- -	- -	- -
Viburnum rufidulum	- -	- -	- -	- -

Effects of Soil Type on the Woody Vegetation

Type 6. This soil, although limited within the refuge, supports the greatest mean basal area, 121.8 ft^2 per acre, and mean density, 389.6 trees per acre, of any woody vegetation. Basing dominance on an importance value of 75 or more (Rice and Penfound 1955), post oak was the only dominant on this soil type (Table I). The important secondary species were blackjack oak and eastern red cedar. Chittamwood, western walnut, netleaf hackberry (*Celtis reticulata*), and American elm were important at times.

Woody reproduction was virtually limited to post oak and blackjack oak (Table II). These two accounted for 13.3 of the 16.8 saplings per acre reproduction.

Herbaceous vegetation within the forests on this soil type was predominantly little bluestem (*Andropogon scoparius*) and big bluestem (*A. gerardi*). The basal area of big bluestem was only a third of that of little bluestem (Table III). No other herbaceous species were significant.

Type 7. Post and blackjack oaks were the dominant species on this soil type (Table I). Eastern red cedar was the only species of secondary importance. Netleaf hackberry and western walnut were present but in limited quantities.

TABLE II. Reproduction of woody species. Number of saplings per acre according to soil types.

Species	6	7	27s	31r
Quercus stellata	6.8	9.7	11.0	1.6
Quercus marilandica	6.5	45.3	41.0	0.7
Juniperus virginiana	2.0	1.6	9.2	4.7
Celtis reticulata	0.7	1.2	1.1	0.9
Cercis canadensis	0.5	- -	- -	- -
Crataegus sp.	0.3	- -	- -	- -
Bumelia lanuginosa	- -	0.3	0.6	1.1
Acer saccharum	- -	- -	13.0	- -
Juglans rupestris	- -	- -	1.4	0.8
Prunus mexicana	- -	- -	0.6	- -
Sapindus drummondii	- -	- -	0.2	0.3
Fraxinus americana	- -	- -	0.1	- -
Morus rubra	- -	- -	- -	0.1
Diospyros virginiana	- -	- -	- -	0.1
Viburnum rufidulum	- -	- -	- -	0.1
Ulmus americana	- -	- -	- -	- -
Quercus shumardii	- -	- -	- -	- -
Quercus macrocarpa	- -	- -	- -	- -
Carya illinoensis	- -	- -	- -	- -
Quercus muhlenbergii	- -	- -	- -	- -
Populus deltoides	- -	- -	- -	- -
Ulmus rubra	- -	- -	- -	- -

While producing the lowest woody basal area and density, this soil type supported the highest herbaceous basal area. It also contained the greatest total number, 39.5, of herbaceous species found in any particular soil type (Table IV).

Blackjack oak had the greatest amount of reproduction with 45.3 saplings per acre. This was followed by post oak with 9.7 saplings per acre. Probably these are not valid data as many of the blackjack 'saplings' were not true saplings but mature individuals in a minimal environment.

Tree dispersal varied widely and was related to exposure. Half of the stands sampled on this soil were on topographically level areas while the remainder were on slope exposures varying from east through south to west. None of the stands was north facing. Those associations subjected to a slope exposure had a much lower basal area than the level ones. 39.6 and 75.0 ft^2 per acre respectively. The lower density in the level stands (Table IV) suggests mature savannah-like associations. The higher density and lower basal area of the more xeric slopes indicate an association of small crowded trees and this is the case (Fig. 3).

<u>Type 27s</u>. Topographically, this soil type was classified into three subdivisions; level, north facing, and

TABLE III. Distribution of three most important herbaceous species according to soil types.
(Mean basal area, per cent cover.)

Species	6	7	27s	31r
Andropogon scoparius	0.72	1.81	1.00	0.63
Andropogon gerardi	0.20	0.19	0.29	0.35
Triders flavus	0.00	0.04	0.05	0.41

south, east, and west facing slopes with the latter three lumped as a group. Post oak was the only dominant species regardless of slope exposure. Important secondary species were blackjack oak, red cedar, and sugar maple (Acer saccharum)

The greatest reproduction of woody species, 41.0 saplings per acre (Table II), on this soil type was that of blackjack oak. Sugar maple was second with 13.0 saplings per acre, and reproduction of this species was not encountered on any other soil. The third species in importance was post oak which had 11.0 saplings per acre. Survival and maturation of the latter is the most probable. The low importance value of blackjack oak on this soil type indicates that either little of the reproduction reaches maturity or blackjack oak is becoming more important. The self thinning of this species has been reported by Liming (1942).

The dominant herb in these forests and on the refuge (Table V) was little bluestem with a basal area almost four-fold that of the next most important species, big bluestem (Table III). The most commonly encountered forb was western ragweed (Ambrosia psilostachya) which occurred on all exposures. Coralberry (Symphoricarpos orbiculatus), a shrub, was common on the north facing and level exposures but quite limited on the south-east-west facing slopes. Several greenbriers (Smilax spp.) including saw greenbrier (S. bona-nox) exhibited the same type distribution, all being restricted to more mesic localities.

The mean tree basal area of all stands on this soil was 86.9 ft^2 per acre. The south, east, and west facing exposures had a basal area of 79.2, lower due to the more xeric conditions typically encountered. North facing stands had a basal area of 89.3, and the level stands 110.0 ft^2 per acre.

The greatest density was found on the north facing slopes where 388.6 trees per acre (Table IV) occurred (Fig. 4). The total number of woody species encountered (16) was

TABLE IV. Average values of sampling data based on soil types and exposures.

Soil Type	Woody Basal Area	Herb Basal Area	Woody Plant Density	No. Species Trees	No. Species Herbs
6	121.8	2.3	389.6	7.2	33.4
7 All Exposures	66.5	4.2	200.3	3.8	39.5
SEW Slope	39.6	2.4	217.5	4.0	28.0
Level	75.0	4.7	192.0	3.6	43.3
27s All Exposures	86.9	2.3	338.9	5.3	35.6
SEW Slope	79.2	2.7	235.4	4.0	35.6
North Slope	89.3	1.8	388.6	6.4	34.8
Level	110.0	2.5	361.9	5.0	37.8
31r	102.0	3.0	277.2	9.5	35.0

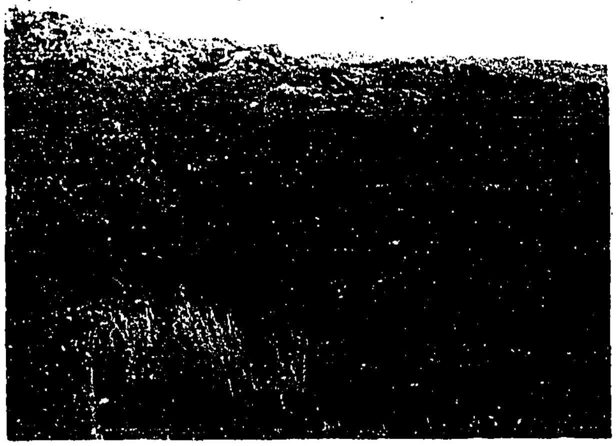

Fig. 3. South facing slope on 7 soil type. The small scrubby trees are blackjack oak. The change from 7 to 27s soil type is evident in the background.

Fig. 4. North facing slope of 27s soil type and exposed rock. The tree in the foreground is post oak. Herbaceous vegetation is scattered.

second only to that found on the soil of the drainageways where a total of 21 species were found. Smooth sumac (Rhus glabra) and roughleaf dogwood (Cornus drummondii) were two common shrubs, nearing tree size, on this exposure.

Herbaceous basal area was lowest on the north facing slopes (Table IV), and highest on the south, east, and west facing exposures where the woody density was lowest.

Type 31r. Post oak was the only dominant occurring on this soil type. However, its importance value averaged 60 points lower than on the other soil types. Other important trees were blackjack oak, red cedar, western walnut, chittamwood, American elm, and chinquapin oak.

The lower importance values of woody species on this soil were paralleled by similar decreases in the overall importance of the leading herbaceous species. The trend from a few highly important species to many less important ones is due to the more mesic conditions. The herb with the greatest basal area in the forests on this soil type was little bluestem (Table III). No specific herbaceous species could be picked out as indicative of this soil type. The great variety of soil formations, structures, and textures, plus the increased available water resulted in a wider range of grasses and forbs.

TABLE V. Herbaceous vegetation with a mean basal area of 0.02 per cent or greater in the 52 sampled stands.

Species	Number of stands in which present	Mean Basal Area
Andropogon scoparius	49	0.99
Andropogon gerardi	37	0.30
Tridens flavus	26	0.18
Bouteloua hirsuta	2[illegible]	0.16
Sporobolus asper	29	0.15
Muhlenbergia racemosa	16	0.14
Carex sp.	19	0.10
Andropogon saccharoides	14	0.07
Chloris verticillata	13	0.05
Bouteloua curtipendula	12	0.05
Symphoricarpos orbiculatus	12	0.05
Muhlenbergia frondosa	9	0.05
Sporobolus cryptandrus	4	0.05
Sorghastrum nutans	11	0.04
Buchloe dactyloides	4	0.04
Cyperus sp.	9	0.03
Panicum lanuginosum	9	0.03
Uniola latifolia	6	0.02
Setaria viridis	5	0.02
Elymus virginicus	4	0.02

Woody basal area was higher here than in the 7 or 27s soils and the density lower than on 6 and 27s types (Table IV). The basal area of chittamwood, netleaf hackberry, western walnut, and American elm on this soil was significantly greater than on other types (Tables VII, VIII, IX, and XI). These data indicate fewer but larger trees in the drainageways. In one stand containing a large number of post oaks, a specimen was found measuring 40 in. DBH. In a second stand a number of chinquapin oaks with a DBH of 30 in. were encountered. Many less stable drainageways support a less impressive woody vegetation (Fig. 5).

Eastern red cedar had the greatest reproduction with 4.7 saplings per acre. Post oak and chittamwood were next with 1.6 and 1.1 saplings per acre respectively. The low reproductive rate is probably due to the relatively dense canopies, the eroding powers of the heavy spring rains concentrated in these areas, and the increased trampling and browsing by the many deer.

Vegetation and Soil Type Relationships

Specific variations in vegetational distribution by soil types are generally due to moisture relationships. Of the eight stands sampled on type 7 soil, five were on the

Post Oak Conglomerate, a formation with little soil. The most xeric forest conditions were found on south facing slopes of type 7 soils, all of which were on the Post Oak Conglomerate formation. The increased insolation, on a soil already poor in water holding potential, is reflected in the low woody basal area and increased importance of scrubby blackjack oak (Fig. 3). This is the only type soil within the refuge on which blackjack oak becomes a dominant. The increase in woody basal area on the level stands is probably a result of two factors, the natural increase of available water on level areas over slope exposures, and the fact that two of the level stands were on gabbro derived soil.

The highest basal area and density values for any soil type occurred on type 6 soils, and again this was probably a result of increased moisture relationships. Each stand of type 6 soil was located at the base of a mountain (Soil Conservation Service 1961). As pointed out by Evans (1922) the disintegration and decomposition of rocks in the refuge is occurring more rapidly than their erosion and transportation. Heavy rains wash soil particles down from the bare rocky outcrops at an increasing velocity until the waters reach the bottom where they quickly spread out and lose their competence. The coarser materials are dropped first and the finer ones last. Consequently, a band of varying width composed of coarse soil particles develops along the bases of the mountains. Lighter rains moving more slowly down the mountain sides add to the available water by forming seeps at the base (Osborn and Allan 1949).

Woody vegetation does not occur uniformly on this soil type from the base of the mountain outward. As less moisture is available the trees drop out and grasses become the dominant vegetation (Fig. 6). The blackjack oak of these stands was located, for the most part, around the perimeter of the woody vegetation. Its occurrence apparently coincided closely with a decrease in soil moisture, due variously to shallow soils, increased drainage, and distance from the mountain.

The basal area of post oak was found to be significantly greater on type 6 soil than any other (Table X). The central portions of stands on this soil type consisted virtually of pure post oak (Fig. 7).

The most distinctive characteristic of the 27s soil type was the presence of sugar maple on the more mesic slopes. A small amount was found on the 31r soils but the greater basal area and density of sugar maple occurred on 27s soils (Tables VI and XII).

Fig. 5. Clusters of chinquapin oaks in Hollis Canyon. This is an example of an Alluvium geologic formation and 31r soil type.

Fig. 6. Woody vegetation distributed around the base of a 27s soil type rocky outcrop. The trees are limited to the band of moist soil.

As basal area data were gathered for herbaceous vegetation on 27s soil type, point frame contacts with exposed rocks were recorded. On the level stands, containing the greatest herbaceous basal area, a total of 2.5 per cent of the soil surface was found to be exposed rock. The level nature of the forest floor apparently restricted rapid run-off, and the large irregularly shaped boulders, typical of 27s soils, were buried. The south, east, and west facing slopes had 16.6 per cent of the surface as bare rock. The greatest amount of exposed rock, 28.9 per cent, occurred on the north facing slope (Fig. 8). The increased moisture of the northern slopes results in a looser soil more easily eroded. The increase in surface rock is reflected in a decrease in herbaceous basal area (Table IV) when compared with other exposures on this soil.

The greatest basal area values for chittamwood, net-leaf hackberry, western walnut, and American elm occurred on the 31r soil type. Significantly greater densities of chittamwood, western walnut, and American elm occurred on this soil (Tables XIII, XIV, and XVIII). These species have higher moisture requirements and were essentially restricted to the wet loamy drainageways. Other soils support isolated patches of these species under locally unique environmental conditions.

Fig. 7. A pure stand of post oak on 6 soil type. The dense canopy and heavy litter result in lower herbaceous vegetation values.

Fig. 8. North facing slope of 27s soil type on Lugert geologic formation. Large rocks cover 28.9 per cent of the surface thus reducing herbaceous vegetation.

TABLE VI. Effects of soil types on basal area of *Acer saccharum*.

Soil Type	N#	Basal area (Mean ± S.E.)	6	7	27s
6	5	0.0 ± 0.0			
7	8	0.0 ± 0.0			
27s	22	4.46 ± 1.9	*	*	
31r	17	0.3 ± 0.03	**	**	*

*Significant at 5% level.
**Significant at 1% level.
#Number of stands.

TABLE VII. Effects of soil types on basal area of *Bumelia lanuginosa*.

Soil Type	N#	Basal area (Mean ± S.E.)	6	7	27s
6	5	0.58 ± 0.16			
7	8	0.09 ± 0.09	*		
27s	22	0.45 ± 0.02	*	**	
31r	17	1.64 ± 0.61		*	

*Significant at 5% level.
**Significant at 1% level.
#Number of stands.

TABLE VIII. Effects of soil types on basal area of *Celtis reticulata*.

Soil Type	N#	Basal area (Mean ± S.E.)	6	7	27s
6	5	0.38 ± 0.24			
7	8	0.09 ± 0.06			
27s	22	0.15 ± 0.09			
31r	17	0.78 ± 0.21		**	**

**Significant at 1% level.
#Number of stands.

TABLE IX. Effects of soil types on basal area of *Juglans rupestris*.

Soil Type	N#	Basal area (Mean ± S.E.)	6	7	27s
6	5	2.4 ± 1.6			
7	8	0.47 ± 0.46			
27s	22	2.03 ± 1.67			
31r	17	11.2 ± 2.54	**	**	**

**Significant at 1% level.
#Number of stands.

TABLE X. Effects of soil types on basal area of *Quercus stellata*.

Soil Type	N#	Basal area (Mean ± S.E.)	6	7	27s
6	5	92.5 ± 9.56			
7	8	53.1 ± 12.5	*		
27s	22	60.3 ± 5.58	**		
31r	17	52.9 ± 8.74	**		

*Significant at 5% level.
**Significant at 1% level.
#Number of stands.

TABLE XI Effects of soil types on basal area of *Ulmus americana*.

Soil Type	N#	Basal area (Mean ± S.E.)	6	7	27s
6	5	0.19 ± 0.10			
7	8	0.19 ± 0.17			
27s	22	0.27 ± 0.17			
31r	17	6.33 ± 1.41	**	**	**

**Significant at 1% level.
#Number of stands.

TABLE XII. Effects of soil types on density of <u>Acer saccharum</u>.

Soil Type	N#	Density (Mean ± S.E.)	6	7	27s
6	5	0.0 ± 0.0			
7	8	0.0 ± 0.0			
27s	22	29.8 ± 4.05	**	**	
31r	17	0.44 ± 0.43			**

**Significant at 1% level.
#Number of stands.

TABLE XIII. Effects of soil types on density of <u>Bumelia lanuginosa</u>.

Soil Type	N#	Density (Mean ± S.E.)	6	7	27s
6	5	2.5 ± 1.37			
7	8	0.31 ± 0.31			
27s	22	1.36 ± 0.58	*	*	
31r	17	10.1 ± 3.66	**	**	**

*Significant at 5% level.
**Significant at 1% level.
#Number of stands.

TABLE XIV. Effects of soil types on density of *Carya illinoensis*.

Soil Type	N#	Density (Mean ± S.E.)	6	7	27s
6	5	0.0 ± 0.0			
7	8	0.0 ± 0.0			
27s	22	0.0 ± 0.0			
31r	17	7.05 ± 3.26	*	*	*

*Significant at 5% level.
#Number of stands.

TABLE XV. Effects of soil types on density of *Celtis reticulata*.

Soil Type	N#	Density (Mean ± S.E.)	6	7	27s
6	5	4.8 ± 2.33			
7	8	0.71 ± 0.67			
27s	22	1.02 ± 0.60			
31r	17	7.2 ± 3.0		*	

*Significant at 5% level.
#Number of stands.

TABLE XVI. Effects of soil types on density of *Juglans rupestris*.

Soil Type	N#	Density (Mean ± S.E.)	6	7	27s
6	5	7.5 ± 6.33			
7	8	0.94 ± 0.93			
27s	22	8.95 ± 6.77			
31r	17	24.5 ± 9.18		*	

*Significant at 5% level.
#Number of stands.

TABLE XVII. Effects of soil types on density of *Quercus marilandica*.

Soil Type	N#	Density (Mean ± S.E.)	6	7	27s
6	5	62.5 ± 43.8			
7	8	65.6 ± 26.1			
27s	22	84.4 ± 18.1			
31r	17	24.3 ± 6.04			**

**Significant at 1% level.
#Number of stands.

TABLE XVIII. Effects of soil types on density of <u>Ulmus americana</u>.

Soil Type	N#	Density (Mean ± S.E.)	6	7	27s
6	5	1.0 ± 1.0			
7	8	0.31 ± 0.31			
27s	22	1.55 ± 0.89			
31r	17	16.2 ± 5.18	**	**	**

**Significant at 1% level.
#Number of stands.

The relatively small areas encompassed by the several soil types and the presence of the same general climatic conditions do not allow the development of distinctively different vegetational associations. The vegetational variations by soil types are a result of modified moisture relations. These relations, probably regulated by the moisture retaining potentials of the soils and slope exposure, are responsible for a series of vegetational associations differing chiefly in relative abundance of the common dominant, post oak. Perhaps it would be best to describe the woody vegetation of the refuge as a continuum. The edaphic and topographic factors are combined in many areas in such a manner that they produce microclimates responsible for the distribution of the several minor species indicative of different soil types.

Effects of Geologic Formations on Woody Vegetation

Alluvium. The soils of this formation are a composite of materials washed into the lower areas. Of the ten alluvial stands sampled six were on 31r soil type and the rest on type 6. Consequently, the vegetational associations were quite similar to those described previously. Post oak was the only dominant species. Secondary species were western walnut, blackjack oak, red cedar, chinquapin oak, and chittamwood in descending order of their importance.

The highest tree density and the second highest basal area for any geologic formation occurred here (Table XX). The species with the second highest importance value, western walnut, was the most significant statistically. Its density was significantly greater on this geologic formation than on all others (Table XXIX), and its basal area was significantly greater here than on Gabbro, Quanah, and Post Oak formations (Table XXV). The only other species on this formation which was significantly important in any respect was chittamwood (Tables XXIV and XXVII).

Post oak was reproducing at the rate of 4.7 saplings per acre and red cedar at 3.8 (Table XXII). Although chinquapin oak had a mean importance value of 19.9 (Table XIX), no reproduction was encountered. Virtually all of the chinquapin trees had a clustered growth form, several boles developing from a common root (Fig. 5).

The most important herbaceous species was little bluestem which made up approximately 25 per cent of the total herbaceous basal area (Table XX) Big bluestem and purpletop (Tridens flavus) were the two secondary species and together made up an additional 25 per cent of the basal area. Slender copperleaf (Acalypha gracilens) occurred in all of the alluvial stands but could not be considered an indicator species due to its common occurrence in other geologic formations.

Gabbro. The woody vegetation consisted of almost pure stands of post oak, blackjack oak, and red cedar. The mean importance value of post oak, the only dominant on this geologic formation, was 218.5 (Table XIX). Blackjack oak and red cedar were the important secondary species and had importance values of 39.2 and 22.3 respectively. These three species had a total importance value of 280.0 out of a possible 300. This formation had the greatest woody basal area

TABLE XIX. Mean importance value of woody species according to geologic formation.

Species	Alluvium	Gabbro	Quanah	Post Oak	Lugert
Quercus stellata	140.5	218.5	144.3	180.3	155.9
Juglans rupestris	49.6	4.2	5.6	6.3	6.8
Quercus marilandica	26.3	39.2	29.1	77.7	65.8
Juniperus virginiana	21.8	22.3	30.0	13.9	17.4
Bumelia lanuginosa	10.6	0.05	14.2	2.0	1.7
Ulmus americana	8.7	9.1	10.9	3.2	4.9
Celtis reticulata	8.5	0.8	7.8	1.7	1.4
Prunus mexicana	2.6	0.9	3.4	2.7	1.1
Carya illinoensis	0.07	4.8	8.6	- -	3.5
Fraxinus americana	2.7	- -	6.6	0.01	0.1
Morus rubra	2.1	- -	0.4	0.9	0.5
Sapindus drummondii	0.8	- -	0.4	0.4	0.1
Acer saccharum	0.5	- -	26.5	- -	16.6
Quercus muhlenbergii	19.9	- -	- -	9.9	6.0
Populus deltoides	0.3	- -	- -	- -	0.01
Quercus macrocarpa	1.8	- -	- -	- -	- -
Cercis canadensis	1.0	- -	- -	- -	- -
Diospyros virginiana	0.9	- -	0.1	- -	3.6
Ulmus rubra	0.08	- -	- -	- -	- -
Quercus shumardii	- -	- -	1.5	- -	7.3
Crataegus sp.	- -	- -	- -	- -	- -
Viburnum rufidulum	- -	- -	- -	- -	- -

and the smallest tree density (Table XX).

Both the basal area and density of post oak were significantly greater on the Gabbro than on either the Post Oak or Lugert formations (Tables XXVI and XXX). The density of pecan (*Carya illinoensis*) was also significantly greater than on the Post Oak formation (Table XXVIII).

Out of the 9.7 saplings per acre reproduction on this formation 6.4 were red cedar and 2.5 post oak (Table XXII). The remaining 0.8 was chittamwood. The forests on this formation were composed of mature trees either in the form of savannahs (Fig. 9) or in dense stands with closed canopies and essentially bare floors.

By far the most important herb in these forests was little bluestem followed by silver bluestem (*Andropogon saccharoides*) and tall dropseed (*Sporobolus asper*). The least number of herbaceous species occurred on this formation and it supported one of the lowest herbaceous basal areas (Table XX).

Coralberry, sedges, and flatsedges (*Cyperus spp.*) occurred in 100 per cent of the stands but their presence in other formations rejected them as possible indicator species. No herbaceous species was significantly distinctive to this formation.

TABLE XX. Average values of sampling data based on geologic formations.

Geologic Formation	Woody Basal Area	Herb Basal Area	Woody Plant Density	No. Species Trees*	No. Species Herbs*
Alluvium	107.4	3.2	322.2	9.0	34.2
Gabbro	111.2	2.7	253.3	5.0	32.2
Quanah	92.5	3.3	301.4	9.0	39.1
Post Oak	79.6	3.0	280.3	5.6	38.1
Lugert	91.1	2.3	318.5	5.8	36.0

*Mean number of species encountered per stand.

Quanah. The only dominant woody species on this granitic formation was post oak (Table XIX) and again the two most important secondary species were blackjack oak and red cedar. The relatively high importance value of sugar maple was a result of only one stand on 27s soil type located on a steep north facing slope.

Both the woody basal area and density of this formation were intermediate to the other formations. The Alluvium and Gabbro formations had higher mean basal areas while the Alluvium and Lugert had higher mean density values.

The single stand on 27s soil is reflected in the reproduction data also. Fourteen saplings per acre of sugar

TABLE XXI. Distribution of three most important herbaceous species according to geologic formation. (Mean basal area, per cent cover.)

Species	Alluvium	Gabbro	Quanah	Post Oak	Lugert
Andropogon scoparius	0.78	1.40	0.58	1.31	0.86
Andropogon gerardi	0.41	0.02	1.80	0.33	0.28
Tridens flavus	0.41	0.02	0.30	0.06	0.11

maple were found. Red cedar, post oak, chittamwood, and blackjack oak had a total of 13.5 saplings per acre as a group (Table XXII).

It might be well to point out that vegetation was quite limited on this formation. Of approximately 13 square miles of Quanah geologic formation on the refuge almost all was exposed bare rock with vegetation only in the crevices or ravines (Fig. 10). Groups of trees large enough to be considered forests or woodlands were very limited.

Of the four soil types and five geologic formations on which trees appeared, the Quanah was the only one on which little bluestem was not the leading herb based on the herbaceous basal area. Big bluestem had three times the basal

TABLE XXII. Reproduction of woody species. Number of saplings per acre according to geologic formation.

Species	Alluvium	Gabbro	Quanah	Post Oak	Lugert
Quercus stellata	4.7	2.5	3.0	15.7	4.7
Juniperus virginiana	3.8	6.4	5.5	4.2	8.1
Celtis reticulata	1.4	- -	1.0	0.7	1.3
Juglans rupestris	0.4	- -	- -	- -	2.1
Bumelia lanuginosa	0.2	0.8	3.0	0.4	0.5
Diospyros virginiana	0.2	- -	- -	- -	- -
Cercis canadensis	0.2	- -	- -	- -	- -
Quercus marilandica	0.1	- -	2.0	38.9	39.2
Acer saccharum	- -	- -	14.0	- -	11.4
Sapindus drummondii	- -	- -	1.0	- -	0.3
Prunus mexicana	- -	- -	- -	0.4	0.4
Crataegus sp.	- -	- -	- -	0.2	- -
Viburnum rufidulum	- -	- -	- -	0.2	- -
Fraxinus americana	- -	- -	- -	- -	0.1
Morus rubra	- -	- -	- -	- -	0.1
Ulmus americana	- -	- -	- -	- -	- -
Quercus muhlenbergii	- -	- -	- -	- -	- -
Quercus shumardii	- -	- -	- -	- -	- -
Carya illinoensis	- -	- -	- -	- -	- -
Quercus macrocarpa	- -	- -	- -	- -	- -
Populus deltoides	- -	- -	- -	- -	- -
Ulmus rubra	- -	- -	- -	- -	- -

area of little bluestem (Table XXI). The third herb was purpletop which was approximately half as important as little bluestem.

Western ragweed occurred in all of the stands on the Quanah formation. However, this species was present in 44 of the 52 total stands sampled. It was the most common forb encountered in the forests.

Post Oak. This formation was, for the most part, composed of 7 and 27s soil types. Both of these soil types have a very poor soil development and limited available water. As a result the woody vegetation was subjected to marginal conditions and was often scrubby. These conditions are reflected in the basal area and density data (Table XX). The density, although not the lowest, was next to it and the basal area was the lowest for any geologic formation.

Post and blackjack oaks were the two dominant woody species. Red cedar and chinquapin oak were next in importance. The density of post oak was significantly greater on the Post Oak formation than on the Quanah (Table XXX). Chittamwood density was also greater on this formation than on Gabbro (Table XXVII).

The greatest reproduction was occurring in blackjack oak with 38.9 saplings per acre. Ninety-six per cent of the

Fig. 9. Open savannah-like forests of Gabbro derived 7 soil types. All the trees shown are post oak and the dominant herb is little bluestem.

Fig. 10. General view of Quanah geologic formation. The woody vegetation is limited to ravines and water courses.

saplings found on this formation were those of blackjack oak, post oak, and red cedar (Table XXII).

Little bluestem was the most important herbaceous species followed by big bluestem and tall dropseed. As a result of the wide range of edaphic and topographic conditions encountered on this formation little bluestem was the only herbaceous species which occurred in all stands sampled on this formation. Very clearly no grass nor forb could be picked out as an indicator species.

Lugert. Of the 19 stands sampled on the Lugert formation 15 were on the 27s soil type and the remaining four on 31r or loamy drainageways type. On the drainages the Lugert granite may be partially buried by alluvial material but yet be near enough the surface to be mapped as Lugert and not Alluvium. Nevertheless, the number of 27s soil type stands on this formation resulted in virtually the same data as reported on the soil type itself (Tables IV and XX).

The only woody dominant was post oak. Secondary species were blackjack oak, red cedar, and sugar maple. Of the 24 woody species encountered 18 showed some importance value on this formation. The increased basal area of sugar maple on this formation over that of the Alluvium, Gabbro, and Post Oak was statistically significant (Table XXIII).

TABLE XXIII. Effects of geologic formations on basal area of *Acer saccharum*.

Geologic Formation	N#	Basal area (Mean ± S.E.)	Alluvium	Gabbro	Quanah	Post Oak
Alluvium	10	0.05 ± 0.01				
Gabbro	4	0.0 ± 0.0				
Quanah	5	5.7 ± 5.7				
Post Oak	14	0.0 ± 0.0				
Lugert	19	3.67 ± 1.65	*	*		*

*Significant at 5% level.
#Number of stands.

TABLE XXIV Effects of geologic formations on basal area of *Bumelia lanuginosa*.

Geologic Formation	N#	Basal area (Mean ± S.E.)	Alluvium	Gabbro	Quanah	Post Oak
Alluvium	10	1.28 ± 0.41				
Gabbro	4	0.08 ± 0.07	*			
Quanah	5	2.55 ± 2.06				
Post Oak	14	0.29 ± 0.10	*			
Lugert	19	0.13 ± 0.13				

*Significant at 5% level.
#Number of stands.

TABLE XXV. Effects of geologic formations on basal area of *Juglans rupestris*.

Geologic Formation	N#	Basal area (Mean ± S.E.)	Alluvium	Gabbro	Quanah	Post Oak
Alluvium	10	12.8 ± 4.05				
Gabbro	4	2.32 ± 2.32	*			
Quanah	5	2.0 ± 2.0	*			
Post Oak	14	1.91 ± 0.92	*			
Lugert	19	4.04 ± 2.22				

*Significant at 5% level.
#Number of stands.

TABLE XXVI. Effects of geologic formations on basal area of *Quercus stellata*.

Geologic Formation	N#	Basal area (Mean ± S.E.)	Alluvium	Gabbro	Quanah	Post Oak
Alluvium	10	60.3 ± 12.6				
Gabbro	4	88.4 ± 12.8				
Quanah	5	63.9 ± 20.1				
Post Oak	14	55.3 ± 8.2		*		
Lugert	19	55.9 ± 6.2		*		

*Significant at 5% level.
#Number of stands.

TABLE XXVII. Effects of geologic formations on density of *Bumelia lanuginosa*.

Geologic Formation	N#	Density (Mean ± S.E.)	Alluvium	Gabbro	Quanah	Post Oak
Alluvium	10	10.5 ± 4.08				
Gabbro	4	0.0 ± 0.0	*			
Quanah	5	14.0 ± 11.0				
Post Oak	14	1.8 ± 0.73		*		
Lugert	19	1.4 ± 0.60		*		

*Significant at 5% level.
#Number of stands.

TABLE XXVIII. Effects of geologic formations on density of *Carya illinoensis*.

Geologic Formation	N#	Density (Mean ± S.E.)	Alluvium	Gabbro	Quanah	Post Oak
Alluvium	10	0.0 ± 0.0				
Gabbro	4	4.95 ± 1.56	**			
Quanah	5	13.0 ± 7.96				
Post Oak	14	0.0 ± 0.0		**		
Lugert	19	1.84 ± 1.84				

**Significant at 1% level.
#Number of stands.

TABLE XXIX. Effects of geologic formations on density of *Juglans rupestris*.

Geologic Formation	N#	Density (Mean ± S.E.)	Alluvium	Gabbro	Quanah	Post Oak
Alluvium	10	47.3 ± 13.8				
Gabbro	4	3.30 ± 3.30	*			
Quanah	5	4.0 ± 4.0	*			
Post Oak	14	5.95 ± 3.87	**			
Lugert	19	12.6 ± 7.5	*			

*Significant at 5% level.
**Significant at 1% level.
#Number of stands.

TABLE XXX. Effects of geologic formations on density of *Quercus stellata*.

Geologic Formation	N#	Density (Mean ± S.E.)	Alluvium	Gabbro	Quanah	Post Oak
Alluvium	10	161.4 ± 38.2				
Gabbro	4	168.9 ± 20.6				
Quanah	5	153.0 ± 44.8				
Post Oak	14	166.0 ± 34.5		*	**	
Lugert	19	137.0 ± 11.7		*	**	

*Significant at 5% level.
**Significant at 1% level.
#Number of stands.

The greater density of chittamwood over that on Gabbro was also significant (Table XXVII).

Reproduction was taking place at the rate of 58.7 saplings per acre (Table XXII). Eighty per cent of the saplings were blackjack oak and sugar maple. These high reproduction figures mean little. As pointed out earlier proportionately few blackjacks reach maturity, and in many rocky areas mature sugar maples do not attain large diameters.

The most important herbaceous species was little bluestem. This was followed by big bluestem, purpletop, and green muhly (Muhlenbergia racemosa). The lowest herbaceous basal area was found on this formation, another close correlation with the 27s soil type.

Of the several most commonly encountered forbs none was present on all Lugert formation stands. Sedges and western ragweed were present in about 80 per cent of the stands but were not restricted significantly to any particular formation.

The primary factor which regulated vegetational associations on the geologic formations was probably moisture. The variations in this factor were a result of the type soils derived from each parent material.

The Alluvium formation, composed of products of recent decomposition and degradation, supported a high woody basal area. Both woody and herbaceous associations were typical of bottomland forests. A few species common to these stands and limited elsewhere were Indian grass (Sorghastrum nutans), wirestem muhly (Muhlenbergia frondosa), and spangle grass (Uniola latifolia).

The Quanah formation, the youngest of the igneous materials, had not decomposed to the point where adequate soil was present for the establishment of vegetation. The few areas sampled were carefully selected for their woody vegetation and were not indicative of the formation in general (Fig. 9).

The highest woody basal area was found on the Gabbro formation and the lowest on the Post Oak Conglomerate. The formation of a deep uniform soil on the former and a shallow irregularly coarse soil on the latter resulted in heavy stands of post oak and blackjack oak respectively.

The herbaceous species mentioned in discussing the Alluvium formation did not occur here but on the other hand xeric herbaceous species common to this formation were absent in the Alluvium. Examples were buffalograss (Buchloe dactyloides), blue grama (Bouteloua gracilis), and hairy grama (Bouteloua hirsuta).

The Lugert formation, covering 58 per cent of the refuge, had only one dominant, post oak. Almost all of the Lugert stands were on 27s soil types. As quickly as the soil is washed off the mountain sides into the valleys it becomes part of the Alluvium formation. Consequently, the vegetational description of the Lugert formation was essentially that of the 27s soil type.

Vegetation Related to Soil Type and Geologic Formation

Soil types within the refuge have a greater direct bearing on the woody vegetational associations present than do geologic formations. However, the soil types are closely related to geologic formations and most stands occur on closely related forms. The lowest woody basal area was found on 7 type soil which was, for the most part, on the Post Oak Conglomerate. The lowest woody basal area on geologic formations occurred on the Post Oak.

The Lugert and Quanah formations are similar in structure, both being granitic, but differ in age. Both had low woody basal areas, the difference in mean basal area being only 1.4 ft^2 per acre (Table XX). Most of the 27s soil types were on granitic formations and consequently both the herbaceous and woody data for these soil types and geologic formations were related.

This parallelism is carried through the similar Alluvium formation and 31r soil type to the Gabbro and type 6 soil. The latter pair supported the highest woody basal area on the refuge.

An increased woody basal area very often resulted in a general decrease in herbaceous basal area. A trend in this direction was evident throughout most of the refuge (Fig. 11). Apart from exceptional instances this relationship was consistent. Therefore one might conceivably base a determination of grazing pressure on the fluctuation of herbaceous basal area in a stand of fixed, or at least known, woody basal area. The trend was less evident on the 27s soil (Fig 12). This was probably a result of the generally low basal area of herbs, a consequence of the high percentage of rock outcropping (Fig. 8).

Post oak was the dominant woody species on every soil type and geologic formation. Blackjack oak was the only other dominant and only on the closely related 7 type soil and Post Oak Conglomerate formation. On the basis of importance values the third species of importance on the refuge was eastern red cedar. The importance values (Tables I and

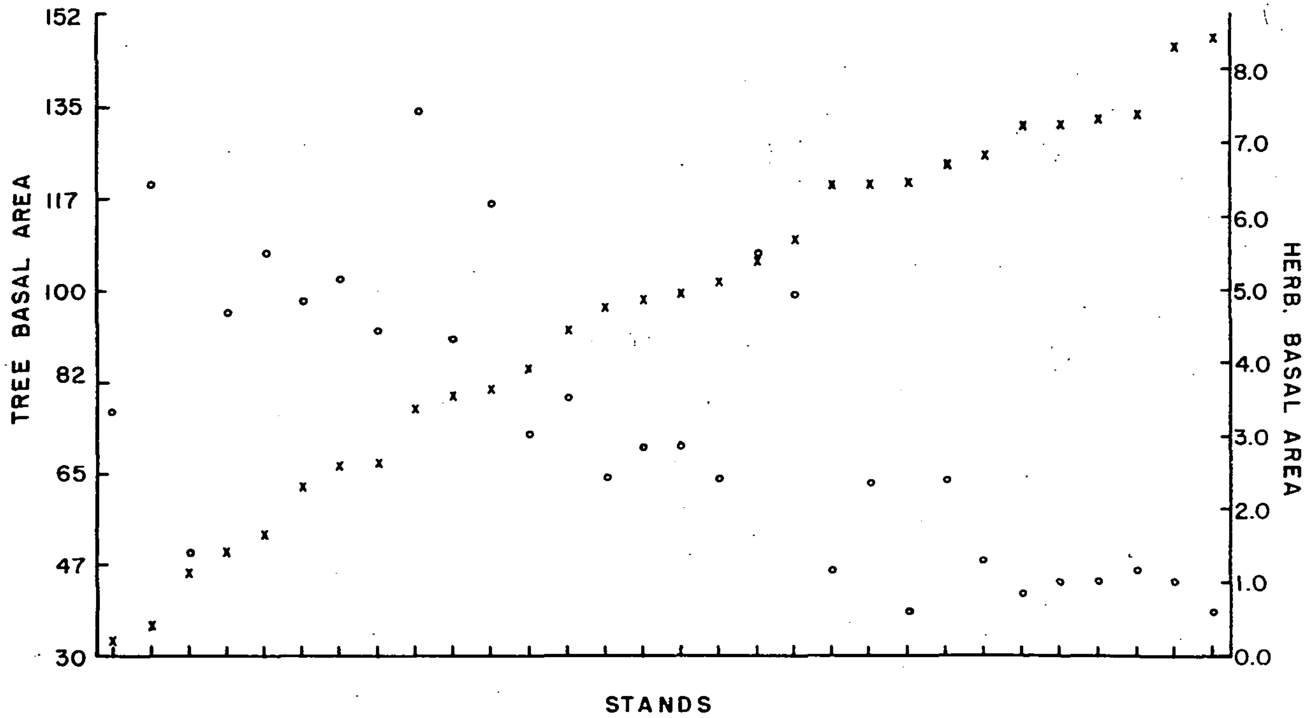

Fig. 11. Relationship of tree basal area to herbaceous basal area in all stands except 27s soil type. The stands are arranged in ascending tree basal area values. The crosses represent tree basal area and the circles the herbaceous basal area.

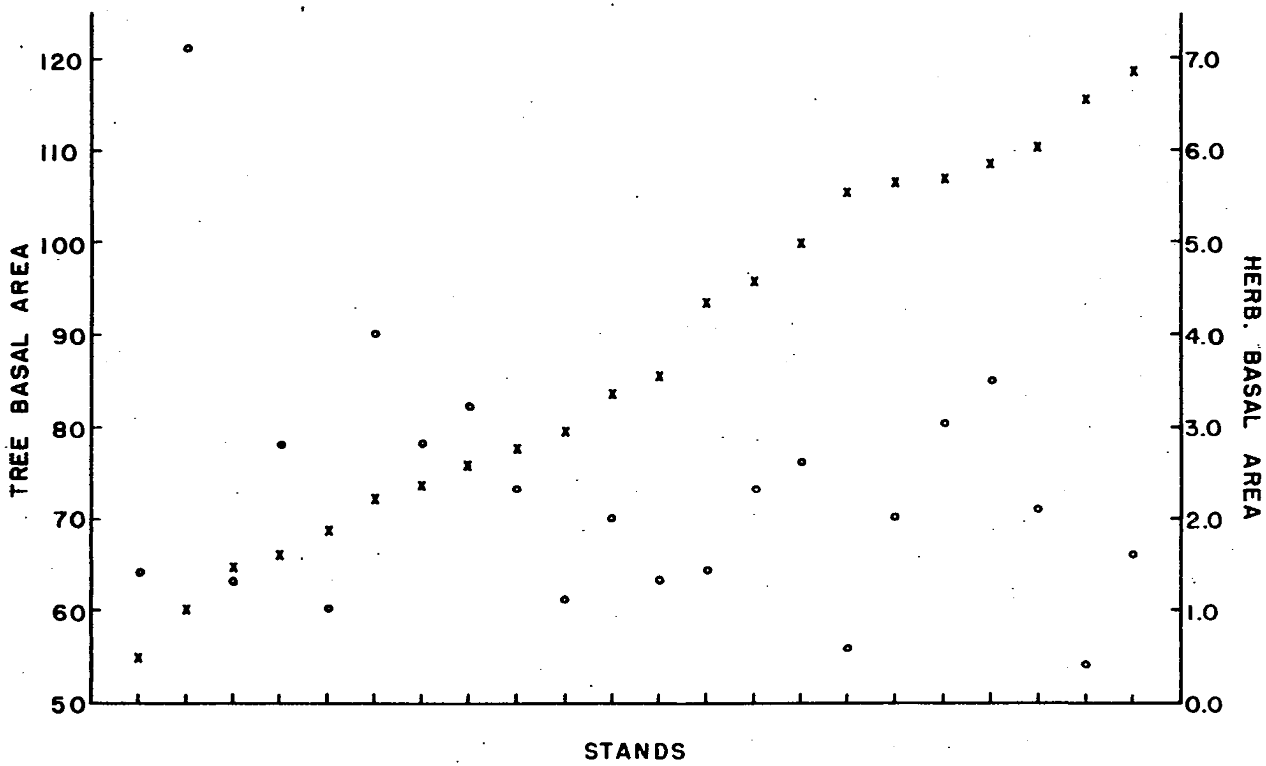

Fig. 12. Relationship of tree basal area to herbaceous basal area in stands on 27s soil type. The stands are arranged in ascending tree basal area values. The crosses represent tree basal area values and the circles the herbaceous basal area values.

XIX) and reproduction data (Tables II and XXII) for this species indicate a universally distributed plant successfully reproducing.

After making a survey of the original 8,000 acre buffalo range, Loring (1906) stated: "it is doubtful if more than 25 cedar trees exist on the preserve." The same area today is spotted with red cedars and this is typical of the refuge. On the basis of Loring's report one must infer that reduced grazing pressure and fire suppression has encouraged the spread and multiplication of cedar. The browsing pressure on this species is light. Rouse (1941) reported that antelope utilize the young tender twigs during the winter.

The fact that it is impossible to clearly outline a particular soil type or geologic formation on the basis of the woody vegetation it supports is due to the relatively small units which have been differentiated and the uniform climatic conditions. A number of unique woody associations are present in the refuge. Examples of these are the sugar maples which are locally dominant, and the western walnut and American elm stands in the valleys, also locally dominant. These formations are not restricted entirely to specific soil types or geologic formations but to modifications of very local environmental conditions. Significant quantitative differences in cover and basal area of individual tree species occur in the refuge. These differences are apparently due to soil type and geology.

SUMMARY

The woody vegetation of the Wichita Mountains Wildlife Refuge in southwestern Oklahoma occurs on four soil types and five geologic formations. Fifty-two relatively undisturbed stands, representative of combinations of these soil types and formations, were located and sampled. Woody basal area, density, frequency, and reproduction were determined by an augmented variable radius method. Basal area of herbaceous vegetation was obtained by a thousand point quadrats with a point frame in each stand.

Post oak (Quercus stellata) was the dominant woody form on all soil types and geologic formations when dominance was based on an importance value of 75 or more. Blackjack oak (Quercus marilandica) was dominant only on type 7 soil and the Post Oak Conglomerate geologic formation, two very closely related forms.

Little bluestem (Andropogon scoparius) was the most prominent herbaceous species on all forms except the Quanah

geologic formation where it was supplanted by big bluestem (Andropogon gerardii).

The greatest reproduction, based on saplings (1.0 in. - 2.9 in. DBH) was occurring on 27s soil types and Lugert geologic formation, two closely related forms. The high reproductive value for blackjack oak suggested an increase in importance for this species. However, this species occurred in virtually pure stands in a scrubby growth form on xeric slopes.

On soil types, other than 27s, a definite trend toward a decrease in herbaceous basal area with an increase in tree basal area was observed.

The delineation of soil types and geologic formations by vegetational associations is not possible due to the limited areas encompassed by each forest or woodland association.

Edaphic and topographic conditions are combined in many areas producing microclimates which support small patches of vegetational associations dominated by species of minor overall importance. An example is the locally dominant sugar maple (Acer saccharum) on the north facing slopes.

Specific vegetational variations on soil types and geologic formations are probably a result of moisture relationships.

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