SOME POPULATION PARAMETERS OF *QUERCUS STELLATA* IN THE TEXAS CROSS TIMBERS

DISSERTATION

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By

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This population study of *Quercus stellata* in the Texas Cross Timbers evaluates that population by observation and sampling of 220 upland forest stands. The Texas Cross Timbers is divided into the East Cross Timbers (ECT) and the West Cross Timbers (WCT) by the Fort Worth Prairie. The parent material of the ECT soils is Woodbine sands and those of the WCT are of Trinity and Paluxy sands. Observation of sharp ecotones between the Cross Timbers areas and the Fort Worth Prairie along with the knowledge of variation in parent materials between the ECT and WCT served as the basis of this study.

Extensive vegetational and soil analyses were done to demonstrate edaphic causes for any vegetational differences that might be observed. Density, per cent frequency, relative per cent of arborescent size classes, and total basal area are the vegetational parameters used in the study. Basal area was determined by the dbh (diameter breast high) method.

Vegetation sampling was by combined line transect-crown intercept and quadrat methods. Phenology of *Q. stellata* in the Texas Cross Timbers was determined for one calendar year.

Soils from each stand were analyzed for texture by the Bouyoucos method. The soils were also analyzed for pH and for total nitrogen, phosphorus, potassium, calcium, and magnesium. U. S. Weather Bureau data for the Texas Cross Timbers area were evaluated for the influence of rainfall and temperature on the *Q. stellata* population.

For statistical comparisons, the Texas Cross Timbers was divided into six north-south divisions. Computer analysis of the data included analysis of variance and the F test.

Statistical analysis of the vegetational data reveals the overall density of *Q. stellata* to be significantly higher in the ECT. The ECT possesses a significantly higher density in all dbh sized larger than 4 cm. The trees of 4 cm. dbh and less were insignificantly higher in mean quantity in the ECT. The total mean basal area and the per cent frequency values were both significantly higher for the ECT. In the north-south regional comparisons, the ECT-north and the ECT-central were highest in all vegetational values with the exception of one size class (4 cm. - 15 cm. dbh). The WCT-central showed the lowest vegetational values.

Soil texture analysis revealed a decreasing per cent of sand from south to north in both the ECT and WCT. There was no significant textural difference between the ECT and WCT.

The mean pH for the ECT soil was 6.57500 while that of the WCT was significantly higher at 6.99286. The mean total nitrogen level was significantly higher in the ECT. The mean total potassium was significantly higher in the WCT. Regional comparisons of edaphic data revealed no significant trends.

The mean annual rainfall is 92 cm. at the eastern edge of the ECT and drops to 62 cm. at the western edge of the WCT. The mean minimum temperature for January follows a decreasing progression from the ECT-south (3.5^{o} C.) to the WCT-north (-1.0^{o} C.).

No correlation trends were noted in comparison of vegetational with edaphic data. The higher vegetational values of the ECT are probably due to the higher rainfall. The trees in the WCT showed a definite clumping tendency. Phenological observation showed a progression of early events (e.g., bud elongation) from southeast to northwest and are related to mean minimum temperature differences.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS--*Continued*

CHAPTER I

INTRODUCTION

The Texas Cross Timbers of North-Central Texas covers a total area of 1,618,000 hectares. The Cross Timbers is divided into eastern and western areas by the Grand Prairie with its clay soils. The East Cross Timbers covers nearly 405,000 hectares and extends southward from the Texas-Oklahoma line at the Red River in eastern Cooke and western Grayson counties, passing just east of Fort Worth and west of Dallas, all the way to Waco in McLennan County. The East Cross Timbers is never more than twenty-four kilometers wide over its entire length. The West Cross Timbers covers an area of 1,214,000 hectares and extends southward from the Red River in western Cooke County and Montague County to Comanche, Brown, and Callahan Counties, where it widens considerably to the west. The West Cross Timbers is approximately forty-eight kilometers wide at the north end and reaches widths of up to one hundred sixty kilometers near the south end (Fig. 1).

Quercus stellata Wang. (post oak) in the Texas Cross Timbers has received only casual attention in the literature.

Hill (1887) observed that post oak (Quercus obtusiloba syn. Quercus stellata Wang.) and blackjack oak (Quercus nigra syn. Quercus marilandica Muenchh.) were dominant Cross Timbers residents. He noted some general similarities in the vegetation of the two Cross Timbers belts, but observed that the trees of the East Cross Timbers attained larger proportions and that there was a larger variety of species in this eastern belt of the Cross Timbers. This, he postulated, was due to greater fertility of the soils in the East Cross Timbers. Tharp (1926) also observed that post oak and blackjack oak were codominants in the Texas Cross Timbers. Dykesterhuis (1948) published a rather detailed phytosociological study for the West Cross Timbers. His map of this western belt served as the initial basis for locating stands to be sampled in this present study. Major emphasis in Dykesterhuis' study was on the importance of the West Cross Timbers as range lands.

Quercus stellata is typically found in upland sandy soils over a rather wide range of area. The species is distributed north from the Texas Cross Timbers into Kansas and Iowa and eastward to New England and to Florida (Vines, 1960). In Texas, Q. stellata is found in several locations outside the Cross Timbers, including the Post Oak Savannah to the east of the Blackland Prairie which separates it from the East Cross Timbers.

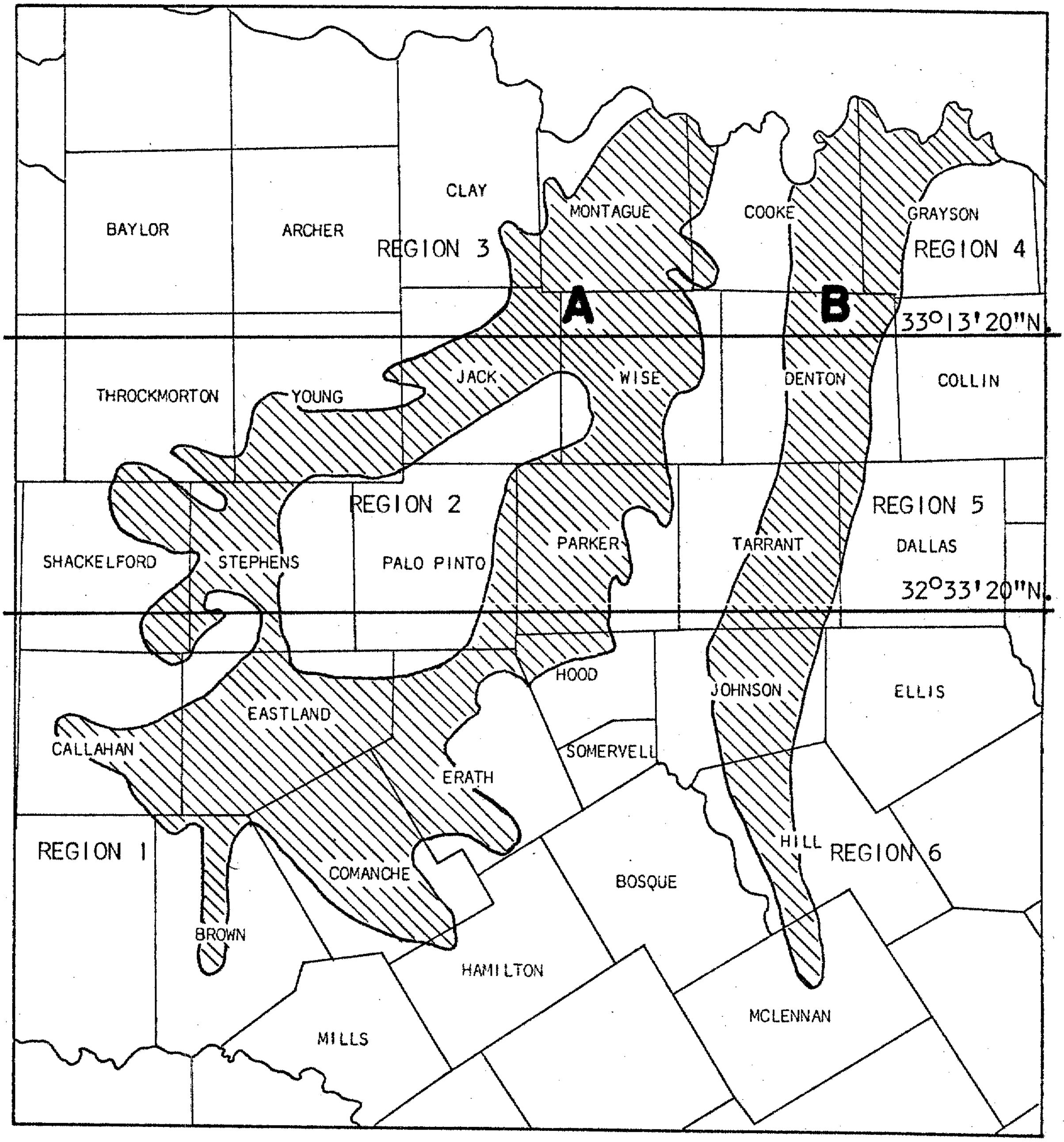


Fig. 1--The Texas West (A) Cross Timbers and the East (B) Cross Timbers. (Modified from Dykesterhuis, 1948, and Tharp, 1952.)

This species is found in outliers southward to the Edwards Plateau and westward to the Rolling Plains (Gould, 1969).

In years past, the wood of *Q. stellata* has been used for railroad crossties, fuel, fence posts, furniture, and lumber. It is presently considered a weedy species by many ranchers, especially in the West Cross Timbers, and large areas are being cleared to provide more grazing areas for cattle.

The several purposes of this study include analysis of the population of *Quercus stellata* in the East and West Cross Timbers of Texas, using density, numbers of trees in each size class, per cent frequency, total basal area, and spacing or distribution as the criteria; the comparison of these parameters between the East Cross Timbers and the West Cross Timbers as well as among the northern, central, and southern regions of both Cross Timbers areas; the analysis of several edaphic and climatic factors that might influence any differences that could be demonstrated in the population of *Q. stellata*; the demonstration of the effect of slope, if any, on any of the population parameters; notation of the phenology of *Q. stellata* throughout the Texas Cross Timbers for one full twelve-month year; and attempts at some prediction of the future of *Q. stellata* in the Texas Cross Timbers.

CHAPTER II

DESCRIPTION OF THE STUDY AREA

Physiography

Hill (1901) described the relief of the East Cross Timbers as that of a greatly dissected dip plain which is sublevel to the east and becomes broken into many low hills toward its western margin. Hill also described the presence of many small areas of prairie, especially along the eastern and western borders of the East Cross Timbers. He also described the presence of a number of knobs through the East Cross Timbers, some being located in Grayson County with others being distributed along the western edge in Denton, Tarrant, and Johnson counties.

The topography of the West Cross Timbers is gently rolling along the eastern edge and in most of the southern region. The relief in the central and western regions of the West Cross Timbers is much more severe, with many high bluffs and steep hillsides. The West Cross Timbers was divided into two north-south belts (Dykesterhuis, 1948) with an eastern "main belt" differing from the western "fringe," where the soil surface contains numerous rocks and boulders of varying sizes (Fig. 2).

Fig. 2--Typical appearance of several of the upland forest areas in the "fringe" belt of the West Cross Timbers of Texas.

The Texas Cross Timbers are dissected by several streams. The northern areas of the East and the West Cross Timbers are in the Trinity watershed, while the southern areas of both Cross Timbers are in the Brazos watershed. Typical floodplain vegetation is found along the streams in these watershed areas.

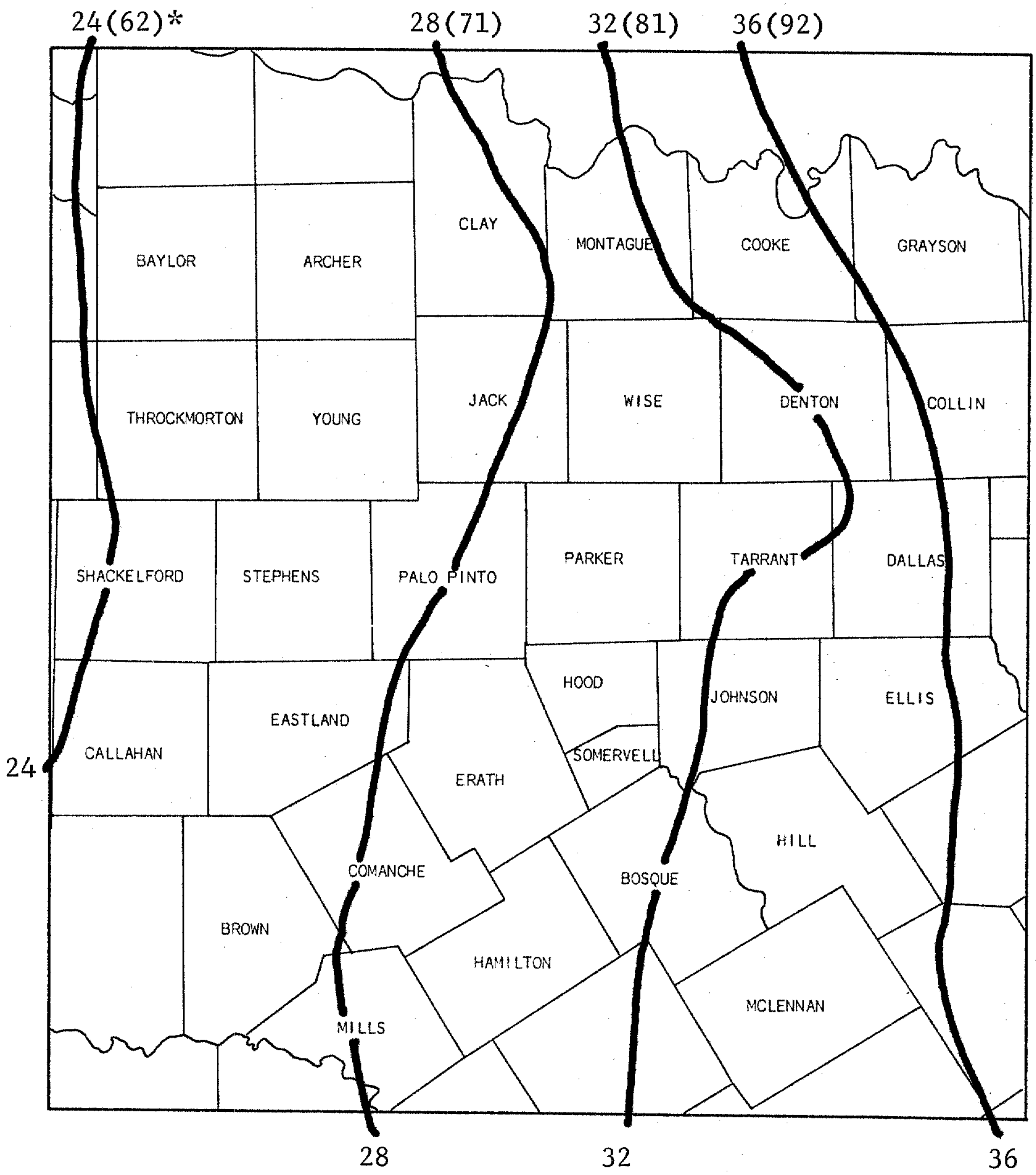
Climate

The climate of the Texas Cross Timbers falls within Thornthwaite's moist-subhumid-mesothermal province (1931, 1941). The area, and especially the West Cross Timbers, is subject to occasional drought. The average annual rainfall (Fig. 3) varies from thirty-six inches (91.5 cm.) at the eastern aspect of the East Cross Timbers to less than twenty-six inches (66 cm.) at the western edge of the West Cross Timbers. April and May are the months of highest rainfall (Table I).

The mean minimum temperature (Fig. 4) ranges from 38^{o}F. (3.5^{o}C.) in the southeastern area of the Texas Cross Timbers to 30^{o}F. (-1^{o}C.) in the northeastern area at the Red River. Maximum temperatures occasionally exceed 105^{o}F. (40.5^{o}C.), and the minimum temperature occasionally drops below 0^{o}F. (-17.5^{o}C.).

Geology and Soils

The Texas Cross Timbers soils are of arenaceous material derived from Cretaceous rock. The East Cross Timbers sands are of Woodbine origin and the sands of the West Cross Timbers are of the Trinity group. In the "fringe" area of the West Cross Timbers the soils are of Pennsylvanian origin (Hill, 1901).



*Values in parentheses represent centimeters.

Fig. 3--Annual rainfall belts in the Texas Cross Timbers. (Adapted from Orton, 1969.)

According to the U. S. Department of Agriculture, Bureau of Chemistry and Soils (1938), the soils of the West Cross Timbers belong mostly to the Windthorst-Nimrod soil association of Zonal Red and Yellow Podzol soils. The few prairie regions within the West Cross Timbers have soils of the Zaneis-Renfrow soil association of Zonal Reddish Prairie soils. In the western, dry portion of the West Cross Timbers there is an azonal type of soil called Immature Reddish Prairie. These latter soils are in the areas of greatest relief.

The East Cross Timbers soils belong to the Norfolk-Ruston soil association of Zonal Red and Yellow Podzol soils.

TABLE I

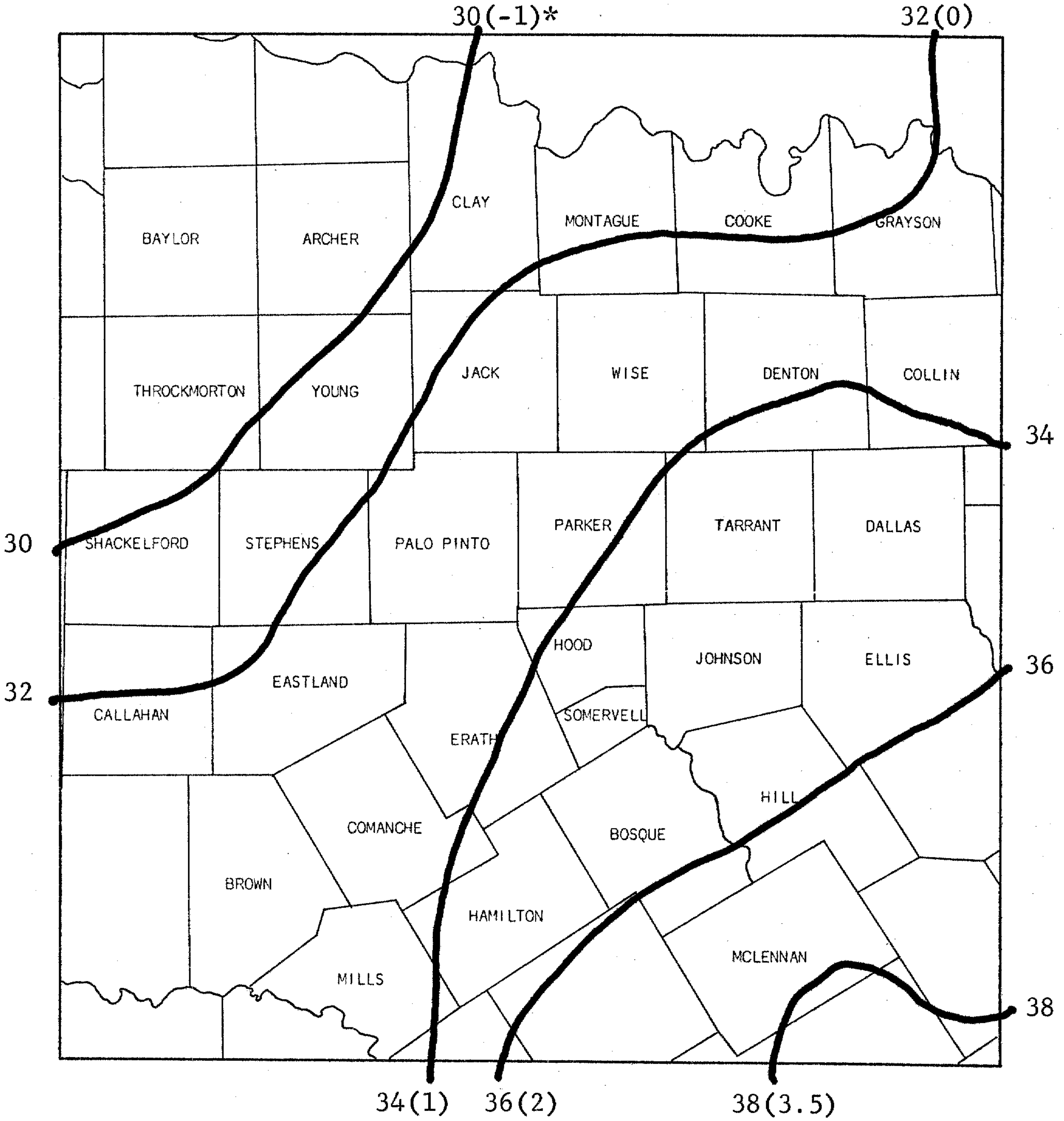
ANNUAL DISTRIBUTION OF MEAN RAINFALL VALUES IN THE TEXAS CROSS TIMBERS

Region	Mean Monthly Rainfall*					
	Jan.	Feb.	Mar.	Apr.	May	Jun.
ECTN Gainesville	1.66 (4.22)	1.74 (4.42)	2.75 (6.99)	3.74 (9.50)	4.94 (12.55)	3.53 (8.97)
ECTC Fort Worth	1.77 (4.50)	1.86 (4.72)	2.49 (6.32)	3.74 (9.50)	4.62 (11.73)	3.28 (8.33)
ECTS Hillsboro	1.73 (4.39)	2.02 (5.13)	2.70 (6.86)	4.65 (11.81)	5.18 (13.16)	2.61 (6.63)
WCTN Bowie	0.91 (2.31)	1.23 (3.12)	2.21 (5.61)	3.06 (7.77)	5.13 (13.13)	3.69 (9.37)
WCTC Eastland	0.99 (2.51)	0.94 (2.39)	1.25 (2.67)	2.17 (5.51)	4.25 (10.80)	3.11 (7.90)
WCTS Brownwood	1.30 (3.30)	1.07 (2.72)	1.50 (3.81)	2.95 (7.49)	3.99 (10.03)	2.79 (7.09)

*Rainfall in inches.
()Rainfall in centimeters.

TABLE I--Continued

Mean Monthly Rainfall--Continued*						Annual Total*
Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
3.92 (9.96)	2.86 (7.26)	3.36 (8.53)	3.32 (8.43)	2.27 (5.77)	2.09 (5.31)	36.18 (91.90)
2.95 (7.49)	2.67 (6.78)	2.54 (6.45)	2.83 (7.19)	2.67 (6.78)	1.96 (4.98)	33.38 (84.79)
2.30 (5.84)	2.87 (7.29)	3.26 (8.28)	2.86 (7.26)	2.92 (7.42)	3.11 (7.90)	36.21 (91.97)
2.39 (6.07)	1.69 (4.29)	2.92 (7.42)	2.99 (7.59)	2.48 (6.32)	1.05 (2.67)	29.75 (75.57)
1.41 (3.58)	3.27 (8.31)	2.43 (6.17)	2.27 (5.77)	2.15 (5.46)	1.68 (4.27)	25.92 (65.84)
1.85 (4.70)	2.21 (5.61)	3.05 (7.75)	2.31 (5.87)	2.14 (5.44)	1.64 (4.17)	26.82 (68.12)



*Values in parentheses represent centigrade.

Fig. 4--Mean minimum temperature (°F.), January, in the Texas Cross Timbers (adapted from Orton, 1969).

CHAPTER III

MATERIALS AND METHODS

Choosing Stands

With the aid of ground reconnaissance, geological survey maps, and aerial photographs, 1,100 upland forest stands were located in the Texas Cross Timbers. Two hundred twenty (one fifth) of these stands were randomly selected for sampling. The stands varied in size from 200 meters square to more than 10,000 meters square. If, for some reason, a randomly-selected stand could not be sampled, the nearest non-selected stand was chosen as an alternate.

Population Analysis

The post oaks were sampled in each stand, using a combination of the line-intercept (Canfield, 1941) and quadrat methods. The starting point of the line transect was placed well into each stand to avoid any ecotone effect. From this starting point, a compass heading was recorded and a 100-meter transect stepped off. At either and of each transect a 10-meter-square quadrat was staked out. All post oak seedlings measuring less than four centimeters in diameter were counted within the two quadrats at each stand and recorded without exact measurement. All trees with a dbh (diameter breast high) of four centimeters or more and whose crowns intercepted the line transect were measured to the nearest centimeter in diameter, using a dbh tape. Observations were recorded at each stand of any out-of-the-ordinary conditions of the post oak population. General impressions were recorded of other arborescent and frutescent species occurring in the study area. Any indications of grazing or other activity of anthropeic origin which could influence the post oak population were also noted.

Five size classes of post oaks were established, as follows:

A (Reproductive)	- Less than 4 cm. dbh
B	- 4 cm. - 15 cm. dbh
C	- 16.5 cm. - 30 cm. dbh
D	- 32 cm. - 41 cm. dbh
E	- 42 cm. + dbh

Edaphic Analysis

At each stand, the direction and general degree of slope were recorded. One large sample of soil was taken from the A horizon to a depth of fifteen centimeters at each stand for later use in texture analysis. Large samples from other soil horizons were also obtained at several stands. The large samples were stored in polyethylene sacks at room temperature. Two small samples of soil were collected (one kilogram) from separate locations along each transect and placed in a freezer within three to four days following collection in order to minimize any chemical change in soil nutrients due to biotic activity. These samples, and several taken from other than the A horizon, were stored for future use for all chemical analyses. Information regarding general soil features was recorded at each stand.

Soil texture analysis was accomplished by the sedimentation method on soil from each stand (Bouyoucos, 1936). Soil pH was determined for each soil sample from a 1:1 dilution, by weight, of distilled water to soil, with a pH meter (Corning, Model 12).

Total nitrogen determination was by the Semimicro Kjeldahl method as modified by Davis (1971). Chemical analyses for total calcium, magnesium, phosphorus, and potassium were achieved by the methods regularly employed by the soil testing laboratories at Texas A & M University. The same soil extract was utilized for the analysis for all four nutrients. Total calcium and total magnesium were analyzed on an Evans Electroselenium

Limited Atomic Absorption Spectrophotometer (EEL-140). The total potassium values were determined with a Perkin-Elmer Atomic Absorption Spectrophotometer (Model 303). Total phosphorus measurements were determined by the color-indicator method of the soil testing laboratories of Texas A & M University, using a light spectrophotometer (Spectronic 20).

Phenology

Phenological observations were made throughout the study area for twelve months beginning in January, 1971, and ending in January, 1972. The same general itinerary, through the entire study area, was travelled weekly to triweekly during the twelve-month period, the frequency depending on the rate of biological activity within the post oak population. In order to minimize differences that might be caused by the effect of slope, all phenological observations were confined to trees on south-facing slopes.

Statistical Analysis

For purposes of identification and comparison, the entire study area was divided into six regions (Fig. 1):

West Cross Timbers

South - Region 1

Central - Region 2

North - Region 3

East Cross Timbers

North - Region 4

Central - Region 5

South - Region 6

Statistical analysis was done by computer at the North Texas State University Computer Center. Data were grouped into several combinations to facilitate statistical analysis. On the basis of the A_1 soil horizon, the groupings were to (1) use all the regions as a single cluster for an overall picture, (2) use Regions 1, 2, and 3 (West Cross Timbers) as one cluster and Regions 4, 5, and 6 (East Cross Timbers) as a second cluster, and (3) use each of the six regions as individual units. The other soil horizons were grouped and evaluated on the basis of Regions 1, 2, and 3 as compared with Regions 4, 5, and 6.

The effect of slope was also compared, using only the A_1 horizon, with the comparisons being made of unsloped, and north-, south-, east-, and west-facing slopes.

Statistical procedures used for data analysis in this study were the analysis of variance and Fisher's *t*. Tabular data comparisons are presented in descending order according to mean values.

CHAPTER IV

RESULTS

During the period of vegetational observation and soil sampling, the study area was undergoing a season of moderate drought. Many of the post oaks in the West Cross Timbers failed to accomplish a complete expansion of young leaves, and many newly-opened leaves, along with the inflorescence, dried before the leaves reached full size (Fig. 5).

Fig. 5--Unexpanded, dried leaves of *Quercus stellata* in the West Cross Timbers of Texas in May, 1971.

This apparent drought effect was not observed in any of the stands in the East Cross Timbers.

While no quantitative assessment was made, considerable insect damage was noted in June, 1971, to the leaves of many post oaks in the West Cross Timbers-north (Fig. 6). The larvae

Fig. 6--Insect damage to leaves of Quercus stellata in the Texas West Cross Timbers-north in June, 1971.

of Cecropia sp. were noted to be in considerable abundance and were observed in the act of consuming leaves.

Very few of the stands in the Texas Cross Timbers, randomly selected for this study, showed any evidence of recent cutting of timber. In the West Cross Timbers, however, several stands had been recently cleared or were in the process, apparently to provide for more grazing area for livestock.

Forty-eight per cent of the stands in the West Cross Timbers showed evidence of recent grazing, while only fourteen per cent of the stands in the East Cross Timbers showed any indications of such recent activity. From casual observation, it appeared that blackjack oak (Quercus marilandica) ran a close second to post oak (Quercus stellata) in density in both the East and the West Cross Timbers. In the West Cross Timbers there was, apparently, a rather high density of winged elm (Ulmus alata Michx.) also.

Using McGinnies' (1934) method for analyzing spacing or distribution of post oaks in the sampling areas, it was noted that there is considerable clumping in the Texas Cross Timbers. The degree of clumping, though, was somewhat higher in the West Cross Timbers than in the East Cross Timbers. In the regional comparisons, the East Cross Timbers-south showed a random distribution of post oaks while the other five regions showed the clumping. In the comparison of slope effect on spacing, the north slope demonstrated a lesser degree of clumping than did the other slopes or the unsloped areas.

There was practically no litter on the forest floor in many of the stands of upland forest in the Texas Cross Timbers. Most of the stands had herbaceous and/or arborescent vegetation growing within the stand. Some of the stands demonstrated a savannah-like appearance rather than that of a true forest stand. Figure 7 is a typical view of this savannah-like appearance, which was observed more frequently in the West Cross Timbers than in the East Cross Timbers.

Fig. 7--View of a savannah-like upland forest stand in the West Cross Timbers of Texas.

Vegetative Analysis

Mean values for the total Texas Cross Timbers vegetation are recorded in Table II.

TABLE II

MINIMUM, MAXIMUM, AND MEAN VEGETATIONAL VALUES FOR <u>QUERCUS</u> <u>STELLATA</u> IN THE TEXAS CROSS TIMBERS

Parameters	Minimum	Maximum	Mean	Std. Dev.	Samples
Density*	7.0	204.0	55.52074	35.80387	217
Size A*	0.0	155.0	22.76959	29.59076	217
Size B*	0.0	69.0	23.30876	14.66419	217
Size C*	0.0	34.0	9.13825	5.72189	217
Size D*	0.0	22.0	0.63134	1.80343	217
Size E*	0.0	2.0	0.04147	0.22181	217
Basal Area**	258.0	15981.0	5402.98248	2588.10250	217
% Frequency	40.0	100.0	87.50000	14.37342	164

*Number of stems per unit sampling area.

**Total basal area, in square centimeters, of all size classes excluding size A.

This table gives evidence of a rather wide range of measurements in several of the vegetational parameters. The data in Table II can serve as a basis of comparison with the values from various arrangements of data organization.

In comparing the vegetational data of the entire East Cross Timbers with that of the entire West Cross Timbers, all mean values for the East Cross Timbers were significantly higher (0.01 level), with the exception of the density of the reproductive size class (Size A) (Table III).

Vegetational comparisons were also made by region, and several significant differences are noted in Table IV. The north and central regions of the East Cross Timbers showed the highest overall density of post oak, as well as in all size classes with the exception of the B size class (4 cm. - 15 cm. dbh). In the B size class the southern region of the West Cross Timbers shared the highest mean density with the central region of the East Cross Timbers. The southern region of the East Cross Timbers showed the lowest mean density value in the reproductive size class (Size A), and the E size class (42 cm. + dbh). The central region of the West Cross Timbers was among the lower density values in all size classes. All three regions of the East Cross Timbers showed higher basal area and per cent frequency values than did the regions of the West Cross Timbers.

TABLE III--Continued

Std. Dev.	D. F.	F Ratio	P
38.62088 33.87196	216	9.1374	0.0028[b]
35.09140 27.27389	216	2.7478	0.0988
16.00353 13.90162	216	6.8850	0.0093[b]
6.85771 5.15277	216	7.4592	0.0068[b]
3.21032 0.83503	216	7.6385	0.0062[b]
0.36574 0.13565	216	6.7933	0.0098[b]
2793.63748 2315.58996	215	26.4346	0.0000[b]
10.31327 14.95042	163	13.6686	0.0003[b]

Slope Effect

The composite vegetational data were analyzed for the effect of slope and the results indicated that the areas with no apparent slope showed a mean basal area value which was significantly higher (0.01 level) than any of the mean values of the sloped areas (Table V). There was no significant difference in per cent frequency among the various slopes. As for the effect of slope on mean overall density and the density of the various size classes, none of the slopes appeared to show indication of any advantages as might be indicated by an increase in density. It was noted, however, that the north slope did have the lowest overall density and the lowest mean density value for several of the size classes.

Soil Analysis

Composite mean values are recorded for the physical and chemical analyses of soils of the Texas Cross Timbers in Table VI.

In the comparison of the soils of the East Cross Timbers with the soils of the West Cross Timbers, there were no significant textural differences in any of the soil particle sizes (Table VII). The mean per cent of sand was slightly higher in the West Cross Timbers, but the mean per cent of

TABLE IV

MINIMUM, MAXIMUM, AND MEAN VEGETATIONAL VALUES OF QUERCUS STELLATA COMPARING THE SIX REGIONS OF THE TEXAS CROSS TIMBERS

Parameters	Region	Minimum	Maximum	Mean[b]
Density[a]	ECTC	29.0	204.0	81.11538
	ECTN	24.0	184.0	73.26667
	WCTS	10.0	172.0	58.36170
	WCTN	12.0	148.0	58.27500
	WCTC	7.0	170.0	42.97297
	ECTS	18.0	69.0	39.06667
Size A[a]	ECTC	0.0	151.0	37.53846
	ECTN	3.0	155.0	37.53333
	WCTN	0.0	107.0	27.72500
	WCTS	0.0	154.0	26.36170
	WCTC	0.0	100.0	13.55405
	ECTS	0.0	15.0	3.40000
Size B[a]	ECTC	2.0	66.0	32.15385
	WCTS	2.0	68.0	25.89362
	ECTS	0.0	53.0	24.26667
	ECTN	4.0	45.0	23.33333
	WCTC	0.0	50.0	20.60811
	WCTN	1.0	51.0	19.15000
Size C[a]	ECTN	1.0	24.0	11.20000
	ECTC	0.0	34.0	10.96154
	WCTN	3.0	21.0	10.90000
	ECTS	1.0	18.0	10.53333
	WCTC	0.0	26.0	8.47297
	WCTS	0.0	17.0	6.57447
Size D[a]	ECTC	0.0	22.0	1.50000
	ECTN	0.0	5.0	1.00000
	ECTS	0.0	9.0	0.86667
	WCTS	0.0	5.0	0.53191
	WCTN	0.0	3.0	0.47500
	WCTC	0.0	4.0	0.35135

TABLE IV--Continued

Std. Dev.	No. Obser.	D. F.	F. Ratio	P
38.76321	26	219	5.6874	0.0000[d]
41.64727	15			
41.10349	47			
29.01281	40			
29.51757	74			
14.00748	15			
35.63283	26	219	4.7815	0.0001[d]
40.40839	15			
20.07561	40			
38.13958	47			
18.81499	74			
4.83735	15			
18.10125	26	219	2.9583	0.0085[d]
14.62760	47			
12.89223	15			
13.59972	15			
13.81067	74			
12.38392	40			
5.97853	15	219	3.5577	0.0022[d]
8.58129	26			
4.92924	40			
4.15532	15			
5.43762	74			
4.00405	47			
4.26380	26	219	2.0132	0.0652
1.51186	15			
2.32584	15			
0.97470	47			
0.81610	40			
0.74819	74			

TABLE IV--Continued

MINIMUM, MAXIMUM, AND MEAN VEGETATIONAL VALUES OF *QUERCUS STELLATA* COMPARING THE SIX REGIONS OF THE TEXAS CROSS TIMBERS

Parameters	Region	Minimum	Maximum	Mean[b]
Size E[a]	ECTN	0.0	2.0	0.20000
	ECTC	0.0	1.0	0.11538
	WCTN	0.0	1.0	0.02500
	WCTS	0.0	1.0	0.02128
	WCTC	0.0	1.0	0.01351
	ECTS	0.0	0.0	0.00000
Basal Area[c]	ECTC	1993.7	15981.6	6900.66200
	ECTN	2180.8	11871.7	6872.24000
	ECTS	4503.5	13181.4	6740.61900
	WCTN	1825.9	14568.6	5647.59700
	WCTC	1684.0	12278.2	4738.68500
	WCTS	296.8	12213.6	4502.26100
% Frequency	ECTS	90.0	100.0	97.50000
	ECTN	70.0	100.0	94.00000
	ECTC	60.0	100.0	93.46154
	WCTS	70.0	100.0	89.09091
	WCTN	60.0	100.0	87.50000
	WCTC	40.0	100.0	82.94118

[a]Number of stems per unit sampling area.

[b]Mean values not connected by vertical line are significantly different.

[c]Total basal area, in square centimeters, of all size classes, excluding Size A.

[d]Significant difference at the 0.01 level.

[e]Significant difference at the 0.05 level.

TABLE IV--Continued

Std. Dev.	No. Obser.	D. F.	F Ratio	P
0.56061	15	219	2.2654	0.0385[e]
0.32581	26			
0.15811	40			
0.14586	47			
0.11625	74			
0.00000	15			
3010.52700	26	218	5.5785	0.0000[d]
2970.69600	15			
2373.31200	15			
2387.33800	40			
2302.11700	73			
2171.97900	47			
5.00000	4	166	3.0550	0.0074[d]
9.10259	15			
11.64210	26			
12.21028	11			
11.92928	40			
16.66696	68			

TABLE V

MINIMUM, MAXIMUM, AND MEAN VEGETATIONAL VALUES OF *QUERCUS STELLATA* COMPARING THE EFFECT OF SLOPE IN THE TEXAS CROSS TIMBERS

Parameters	Slope	Minimum	Maximum	Mean[b]
Density[a]	East	19.0	204.0	69.60606
	West	10.0	132.0	58.16216
	None	18.0	146.0	56.30000
	South	12.0	172.0	54.79245
	North	7.0	184.0	49.79310
Size A[a]	East	0.0	151.0	33.12121
	None	0.0	107.0	27.40000
	South	0.0	154.0	23.35849
	West	0.0	84.0	22.37838
	North	0.0	155.0	18.32184
Size B[a]	West	3.0	68.0	27.51351
	East	1.0	61.0	26.00000
	North	2.0	66.0	22.11494
	South	0.0	69.0	21.96226
	None	0.0	35.0	17.30000
Size C[a]	West	1.0	34.0	10.05405
	East	1.0	26.0	9.90909
	None	4.0	19.0	9.30000
	South	0.0	22.0	8.92453
	North	0.0	22.0	8.47571
Size D[a]	None	0.0	9.0	2.10000
	North	0.0	22.0	0.79310
	East	0.0	2.0	0.51515
	South	0.0	5.0	0.45283
	West	0.0	3.0	0.35135

TABLE V--*Continued*

Std. Dev.	No. Obser.	D. F.	F Ratio	P
44.00209	33	219	1.9340	0.1059
29.00720	37			
37.18139	10			
36.55836	53			
33.24823	87			
38.11312	33	219	1.6012	0.1751
32.20145	10			
31.77148	53			
19.57372	37			
26.92215	87			
16.14796	37	219	1.7376	0.1428
16.08182	33			
13.97957	87			
13.73788	53			
12.06510	10			
7.17614	37	219	0.6213	0.6479
6.43896	33			
4.80856	10			
5.16962	53			
5.08676	87			
2.92309	10	219	2.2570	0.0640
2.47376	87			
0.83371	33			
0.88938	53			
0.71555	37			

TABLE V--Continued

MINIMUM, MAXIMUM, AND MEAN VEGETATIONAL VALUES OF *QUERCUS STELLATA* COMPARING THE EFFECT OF SLOPE IN THE TEXAS CROSS TIMBERS

Parameters	Slope	Minimum	Maximum	Mean[b]
Size E[a]	None	0.0	3.0	0.20000
	East	0.0	1.0	0.06061
	South	0.0	1.0	0.05660
	West	0.0	1.0	0.02703
	North	0.0	1.0	0.01149
Basal Area[c]	None	3174.0	13181.0	7898.53800
	East	1684.0	15982.0	6006.42100
	West	1826.0	14569.0	5361.43800
	South	297.0	11188.0	5162.00000
	North	465.0	11304.0	5104.71900
% Frequency	East	60.0	100.0	91.85185
	West	60.0	100.0	88.00000
	North	40.0	100.0	86.77419
	None	70.0	100.0	86.00000
	South	40.0	100.0	85.78947

[a]Number of stems per unit sampling area.

[b]Mean values not connected by vertical line are significantly different.

[c]Total basal area, in square centimeters, of all size classes, excluding Size A.

[d]Significant difference at the 0.01 level.

TABLE V--Continued

Std. Dev.	No. Obser.	D. F.	F. Ratio	P
0.42164	10	219	1.8912	0.1131
0.24231	33			
0.30478	53			
0.16440	37			
0.10721	87			
3311.93700	10	219	3.3281	0.0114[d]
3012.81800	33			
2760.04200	37			
2312.84800	52			
2173.80700	87			
11.10684	27	166	0.8173	0.5160
13.67694	35			
15.01630	62			
11.40175	5			
16.04581	38			

TABLE VI

MINIMUM, MAXIMUM, AND MEAN EDAPHIC VALUES
FOR THE TEXAS CROSS TIMBERS

Parameters	Minimum	Maximum	Mean	Std. Dev.	Samples
% Sand	41.6	98.0	70.03999	10.88679	210
% Colloids	0.0	44.2	11.88762	7.41093	210
% Coarse Clay	0.0	41.7	9.11333	6.70583	210
% Fine Clay	0.0	34.8	8.17190	6.33155	210
pH	5.0	7.9	6.87799	0.50449	209
Nitrogen*	0.0	504.00	89.04204	95.53081	219
Potassium*	0.0	59.04	14.68282	11.05875	217
Magnesium*	2.8	82.88	19.27525	9.70374	219
Calcium*	0.84	100.80	7.18028	5.32332	219
Phosphorus*	0.0	0.44	0.08544	0.07120	202

*Values expressed in Kg/Hectare.

total colloids, coarse clay, and fine clay was lower than the values in the East Cross Timbers. Regional comparisons showed the southern region of the West Cross Timbers to have the highest per cent of sand, with the lowest per cent of total colloids, per cent of coarse clay, and per cent fine clay (Table VIII). It was also noted that there was decreasing per cent of sand in both the East and the West Cross Timbers

TABLE VII

MINIMUM, MAXIMUM, AND MEAN EDAPHIC VALUES COMPARING THE TEXAS EAST AND WEST CROSS TIMBERS

Parameter	Area	Minimum	Maximum	Mean[b]
% Sand	WCT	41.6	96.0	70.06580
	ECT	43.2	98.0	69.57307
% Colloids	ECT	0.5	44.2	12.78846
	WCT	0.0	38.8	11.69677
% Coarse Clay	ECT	0.0	41.7	9.84231
	WCT	0.0	35.6	8.96000
% Fine Clay	ECT	0.0	40.6	8.63461
	WCT	0.0	34.8	8.09935
pH	WCT	5.3	7.9	6.99286
	ECT	5.0	8.0	6.57500
Nitrogen[a]	ECT	0.0	504.00	151.79900
	WCT	0.0	234.18	66.53800
Potassium[a]	WCT	0.0	59.05	15.95000
	ECT	0.0	45.17	11.41000
Magnesium[a]	WCT	0.0	82.88	19.79000
	ECT	2.8	70.56	18.25000
Calcium[a]	WCT	1.68	100.80	7.54000
	ECT	0.84	15.68	6.39000
Phosphorus[a]	ECT	0.00	0.44	0.08936
	WCT	0.00	0.43	0.08155

[a]Total nutrient level in kilograms/hectare.

[b]Values not connected by a vertical line are not significantly different.

[c]Significant difference at the 0.01 level.

TABLE VII--Continued

Std. Dev.	No. Observ.	D. F.	F Ratio	P
10.44505 12.35620	155 52	206	0.0788	0.7792
8.66045 6.97486	52 155	206	0.8406	0.3604
8.19496 6.17138	52 155	206	0.6689	0.4145
7.84594 5.79153	52 155	206	0.2754	0.6003
0.43673 0.55053	154 52	206	31.0186	0.0000[c]
133.15500 66.73900	56 160	215	38.3343	0.0000[c]
11.46000 9.27000	159 55	213	7.0235	0.0086[c]
9.20000 11.06000	160 56	215	1.0465	0.3073
5.96000 2.73000	160 56	215	1.9302	0.1661
0.07584 0.08155	48 151	198	0.1006	0.7514

TABLE VIII

MINIMUM, MAXIMUM, AND MEAN EDAPHIC VALUES COMPARING THE SIX REGIONS OF THE TEXAS CROSS TIMBERS

Parameters	Region	Minimum	Maximum	Mean[b]
% Sand	WCTS	50.0	96.0	75.19111
	ECTS	47.8	97.2	71.90908
	ECTC	43.2	93.2	70.22307
	WCTC	41.6	91.2	68.38611
	WCTN	48.4	90.2	67.17894
	ECTN	53.2	84.4	66.73333
% Colloids	ECTS	0.5	44.2	14.15454
	WCTC	3.6	38.8	13.08889
	ECTC	1.4	39.4	12.99615
	WCTN	4.8	29.1	12.05263
	ECTN	6.0	22.8	11.42666
	WCTS	0.0	31.0	9.16889
% Coarse Clay	ECTS	0.0	41.7	10.97273
	WCTC	2.8	35.6	10.45833
	ECTC	0.0	37.2	10.10000
	WCTN	2.4	26.8	8.95526
	ECTN	4.0	18.3	8.56667
	WCTS	0.0	30.0	6.56667
% Fine Clay	ECTS	0.0	40.6	9.99091
	WCTC	2.3	34.8	9.55555
	ECTC	0.0	36.2	8.98461
	WCTN	2.4	24.8	8.15263
	ECTN	2.5	15.8	7.03333
	WCTS	0.0	30.0	5.72444
pH	WCTC	5.3	7.8	7.08286
	WCTN	5.8	8.0	6.94210
	WCTS	5.8	7.9	6.89783
	ECTC	5.4	7.8	6.71200
	ECTS	5.0	7.7	6.47500
	ECTN	5.6	7.3	6.42667

TABLE VIII--Continued

Std. Dev.	No. Obser.	D. F.	F Ratio	P
9.25222	45	209	3.0403	0.0072[d]
14.65152	11			
13.35070	26			
10.86154	72			
8.93929	38			
8.41679	15			
11.65996	11	209	1.9600	0.0729
7.93632	72			
9.24032	26			
6.33270	38			
4.48465	15			
5.00962	45			
11.16029	11	209	2.1336	0.0510[c]
7.09865	72			
8.78653	26			
5.30760	38			
3.86590	15			
4.33212	45			
10.83120	11	209	2.3085	0.0353[c]
6.69954	72			
8.39055	26			
4.75893	38			
3.21196	15			
4.08474	45			
0.43870	70	208	7.8910	0.0000[d]
0.49573	38			
0.35683	46			
0.47725	25			
0.69429	12			
0.51888	15			

TABLE VIII--Continued

MINIMUM, MAXIMUM, AND MEAN EDAPHIC VALUES COMPARING THE SIX REGIONS OF THE TEXAS CROSS TIMBERS

Parameters	Region	Minimum	Maximum	Mean[b]
Nitrogen[a]	ECTN	0.0	426.62	197.93500
	ECTS	0.0	305.46	183.26900
	ECTC	0.0	504.00	107.02600
	WCTN	0.0	234.18	80.43900
	WCTC	0.0	234.18	65.38400
	WCTS	0.0	204.66	56.86200
Potassium[a]	WCTC	0.0	59.05	19.8200
	WCTN	0.0	37.09	13.1380
	ECTN	0.0	38.34	13.1250
	WCTS	0.0	39.17	12.1250
	ECTS	0.0	23.21	10.8470
	ECTC	0.0	45.17	10.7200
Magnesium[a]	WCTN	5.04	52.08	21.2080
	WCTC	7.84	82.88	20.8790
	ECTC	5.04	70.56	20.0520
	ECTS	2.80	43.12	18.6670
	WCTS	0.00	68.32	16.9070
	ECTN	7.28	27.44	14.7090
Calcium[a]	WCTC	7.84	82.88	8.2600
	ECTN	3.36	15.12	7.0000
	WCTN	1.68	18.48	6.9930
	WCTS	2.24	56.00	6.8690
	ECTC	1.12	15.68	6.2140
	ECTS	0.84	7.84	6.1040
Phosphorus[a]	ECTS	0.0	0.44	0.1310
	WCTN	0.0	0.55	0.1200
	ECTN	0.0	0.26	0.0940
	WCTC	0.0	0.43	0.0750
	ECTC	0.0	0.17	0.0710
	WCTS	0.0	0.21	0.7000

[a]Total soil nutrient level in kilograms/hectare.

[b]Values not connected by a vertical line are significantly different.

TABLE VIII--Continued

Std. Dev.	No. Obser.	D. F.	F Ratio	P
146.27900	15	218	9.3139	0.0000[d]
67.80300	15			
143.15600	26			
73.55800	39			
68.38000	74			
56.94800	47			
12.888	74	216	4.7406	0.0001[d]
7.863	38			
11.252	15			
9.607	47			
5.880	15			
9.847	25			
10.482	39	218	2.0925	0.0554[c]
8.714	74			
13.744	26			
9.276	15			
8.321	47			
6.100	15			
7.035	74	218	1.1791	0.3185
2.719	15			
4.174	39			
5.318	47			
3.645	26			
1.016	26			
0.149	9	201	2.6791	0.0160[d]
0.111	39			
0.063	15			
0.067	70			
0.042	24			
0.061	42			

[c]Significant difference at the 0.05 level.

[d]Significant difference at the 0.01 level.

from south to north. No other similar textural trends appeared in the statistical analysis.

Analysis of the chemical data, comparing the East Cross Timbers with the West Cross Timbers, showed significantly higher (0.01 level) mean pH and mean total potassium values for the West Cross Timbers (Table VII). The mean total nitrogen value was higher, significantly (0.01 level), in the East Cross Timbers. The only other soil nutrient value that was higher in the East Cross Timbers was mean total phosphorus.

In the chemical comparisons of the soils of the six regions of the Texas Cross Timbers, a number of significant differences were noted (Table VIII). The mean pH values were significantly higher in all three regions of the West Cross Timbers, while the mean total nitrogen values were significantly higher (0.01 level) in the East Cross Timbers. The mean total potassium showed a significantly higher (0.01 level) value in the West Cross Timbers-central than any of the other five regions. While there were some significant differences in magnesium, there appeared to be no south-north or east-west trend. No significant differences were noted in the mean total calcium values among the six regions. There were some significant differences in the phosphorus values, but no regional trends were noted.

Slope Effects on Edaphic Values

Comparisons of the edaphic values with regard to slope showed no overall mean textural trends (Table IX). The south slope did show the highest mean per cent of sand with the lowest mean per cent of total colloids, coarse clay, and fine clay.

Significant differences (0.05 level) were noted in soil pH,with the west slope showing the highest mean value (7.0314); and the mean value for no apparent slope was the lowest (6.590). The area of lowest mean pH, no slope, revealed the highest nitrogen level. While there were no significant differences in mean slope values of nitrogen, potassium, magnesium, and calcium, the east slope yielded the highest quantities for all minerals except for mean total nitrogen. Mean total phosphorus levels showed significant differences (0.05 level) among the six regions with the east slope again showing the highest value. The unsloped value was the lowest for mean total phosphorus.

Subsoil Edaphic Analysis

The edaphic values of all the lower soil horizons (A_2 and below) were statistically evaluated as a clump, comparing the East Cross Timbers with the West Cross Timbers (Table X). The East Cross Timbers showed a higher mean per cent of sand,

TABLE IX

MINIMUM, MAXIMUM, AND MEAN EDAPHIC VALUES COMPARING THE EFFECT OF SLOPE IN THE TEXAS CROSS TIMBERS

Parameters	Slope	Minimum	Maximum	Mean[b]
% Sand	South	50.0	98.0	72.66599
	North	46.4	95.6	70.14337
	East	43.2	89.8	69.49374
	None	49.2	93.2	67.84444
	West	41.6	92.6	67.18888
% Colloids	None	2.3	25.8	13.14444
	North	1.3	44.2	12.49397
	East	4.2	35.3	12.33125
	West	3.6	36.3	11.94444
	South	0.0	31.0	10.33000
% Coarse Clay	East	0.0	32.8	9.77500
	None	1.8	19.3	9.72222
	North	0.0	41.7	9.52048
	West	2.4	34.8	9.18889
	South	0.0	30.0	7.85000
% Fine Clay	East	0.0	30.8	8.74062
	North	0.0	40.6	8.61325
	West	2.3	33.8	8.31389
	None	0.0	15.8	7.93333
	South	0.0	30.0	7.01600
pH	West	6.0	7.9	7.03143
	East	6.0	8.0	6.98387
	South	5.4	7.8	6.89000
	North	5.0	7.9	6.80120
	None	5.9	7.3	6.59000
Nitrogen[a]	None	0.0	260.66	117.70200
	South	0.0	426.62	96.51500
	West	0.0	504.00	90.17800
	North	0.0	386.90	85.07100
	East	0.0	427.64	77.19000

TABLE IX--Continued

Std. Dev.	No. Obser.	D. F.	F Ratio	P
8.89025	50	209	1.4712	0.2122
11.20105	83			
11.72571	32			
14.24738	9			
10.73437	36			
8.88680	9	209	0.7817	0.5382
8.46929	83			
7.41569	32			
6.96232	36			
5.32860	50			
7.10315	32	209	0.6131	0.6537
6.73791	9			
7.75471	83			
6.00736	36			
4.87753	50			
6.58144	32	209	0.5850	0.6738
7.46582	83			
5.45654	36			
6.35157	9			
4.53059	50			
0.43235	35	208	2.5252	0.0420[c]
0.51517	31			
0.49380	50			
0.53225	83			
0.30714	10			
100.49200	10	218	0.4635	0.7625
100.08300	53			
113.21800	37			
81.66700	87			
102.48800	32			

TABLE IX--Continued

MINIMUM, MAXIMUM, AND MEAN EDAPHIC VALUES COMPARING THE EFFECT OF SLOPE IN THE TEXAS CROSS TIMBERS

Parameters	Slope	Minimum	Maximum	Mean[b]
Potassium[a]	East	0.0	46.22	15.903
	North	0.0	44.12	15.126
	South	0.0	59.05	14.984
	West	0.0	43.51	13.133
	None	0.0	33.15	11.213
Magnesium[a]	East	8.40	52.08	22.803
	None	6.20	52.08	22.400
	North	5.00	82.88	19.040
	South	0.00	54.32	18.522
	West	7.84	76.16	17.012
Calcium[a]	East	3.36	100.80	9.099
	West	3.36	16.80	6.970
	North	0.84	56.00	6.903
	South	1.40	31.92	6.773
	None	1.96	17.92	6.356
Phosphorus[a]	East	0.0	0.32	0.110
	South	0.0	0.43	0.098
	West	0.0	0.31	0.091
	North	0.0	0.26	0.072
	None	0.0	0.09	0.035

[a]Total soil nutrient level in kilograms/hectare.

[b]Values not connected by a vertical line are significantly different.

[c]Significant difference at the 0.05 level.

[d]Significant difference at the 0.01 level.

TABLE IX--Continued

Std. Dev.	No. Obser.	D. F.	F Ratio	P
10.212	32	216	0.5619	0.6907
11.515	87			
12.755	53			
8.338	37			
9.466	10			
12.632	32	218	1.9452	0.1041
13.781	10			
9.945	87			
6.903	53			
7.759	37			
5.266	32	218	1.2669	0.2840
3.014	37			
5.925	87			
5.620	53			
4.542	10			
0.085	29	201	2.5298	0.0418[c]
0.090	49			
0.100	35			
0.060	80			
0.033	9			

TABLE X

MINIMUM, MAXIMUM, AND MEAN EDAPHIC VALUES FROM SUBSOIL COMPARING THE EAST AND WEST TEXAS CROSS TIMBERS

Parameters	Area	Minimum	Maximum	Mean[b]
% Sand	ECT	58.2	95.6	80.49443
	WCT	43.2	96.8	67.09000
% Colloids	WCT	2.0	36.6	18.71500
	ECT	0.5	22.4	7.68333
% Coarse Clay	WCT	0.0	35.6	16.94000
	ECT	0.0	20.4	5.71667
% Fine Clay	ECT	0.0	34.8	15.93500
	ECT	0.0	19.4	5.15000
pH	ECT	6.2	7.6	7.06667
	WCT	5.3	7.8	6.87000
Nitrogen[a]	ECT	0.0	202.94	77.45664
	WCT	0.0	204.23	56.10192
Potassium[a]	WCT	0.0	43.51	14.79396
	ECT	0.0	3.38	3.34009
Magnesium[a]	WCT	0.00	78.40	36.14800
	ECT	5.04	33.04	13.50223
Calcium[a]	WCT	2.24	100.80	13.33111
	ECT	1.12	4.20	2.36444
Phosphorus[a]	ECT	0.0	0.26	0.14373
	WCT	0.0	0.21	0.05740

[a]Total soil nutrient level in kilograms/hectare.

[b]Values not connected by a vertical line are significantly different.

[c]Significant difference at the 0.05 level.

TABLE X--*Continued*

Std. Dev.	No. Obser.	D. F.	F Ratio	P
18.49443 17.16032	6 20	25	2.7267	0.1117
12.26463 8.59288	20 6	25	4.1771	0.0521[c]
12.22294 7.85195	20 6	25	4.4339	0.0459[c]
11.88702 7.55188	20 6	25	4.3383	0.0481[c]
0.53541 0.71458	6 20	25	0.3848	0.5409
72.45664 74.63895	9 20	28	0.5024	0.4845
15.30068 7.53153	18 9	26	4.4385	0.0453[c]
28.13611 13.58922	20 9	28	5.2029	0.0307[c]
25.02464 1.52794	18 9	26	1.6916	0.2052
0.14983 0.07661	6 16	21	3.2479	0.0866

but the West Cross Timbers showed a significantly higher value (0.05 level) in per cent colloids, per cent coarse clay, and per cent fine clay. The mean levels of potassium and magnesium were significantly higher (0.05 level) in the West Cross Timbers also.

Soil Texture

Using the United States Department of Agriculture soil texture classification system, the texture of the West Cross Timbers soils varies from loamy sand to sandy loam (Figs. 8, 9, and 10). In the East Cross Timbers the soil is nearly all sandy loam in texture (Figs. 11, 12, and 13).

Phenology

In the spring, the first biotic activity in the post oaks was observed in the southern region of the East Cross Timbers. First activity, bud-elongation, was observed simultaneously in the southern region of the West Cross Timbers and the central region of the East Cross Timbers. Then, simultaneous first activity was observed in the East Cross Timbers-north and the West Cross Timbers-central. The West Cross Timbers-north was the last of the regions to show bud-elongation (Table XI). Through the remainder of the growing season, events occurred simultaneously.

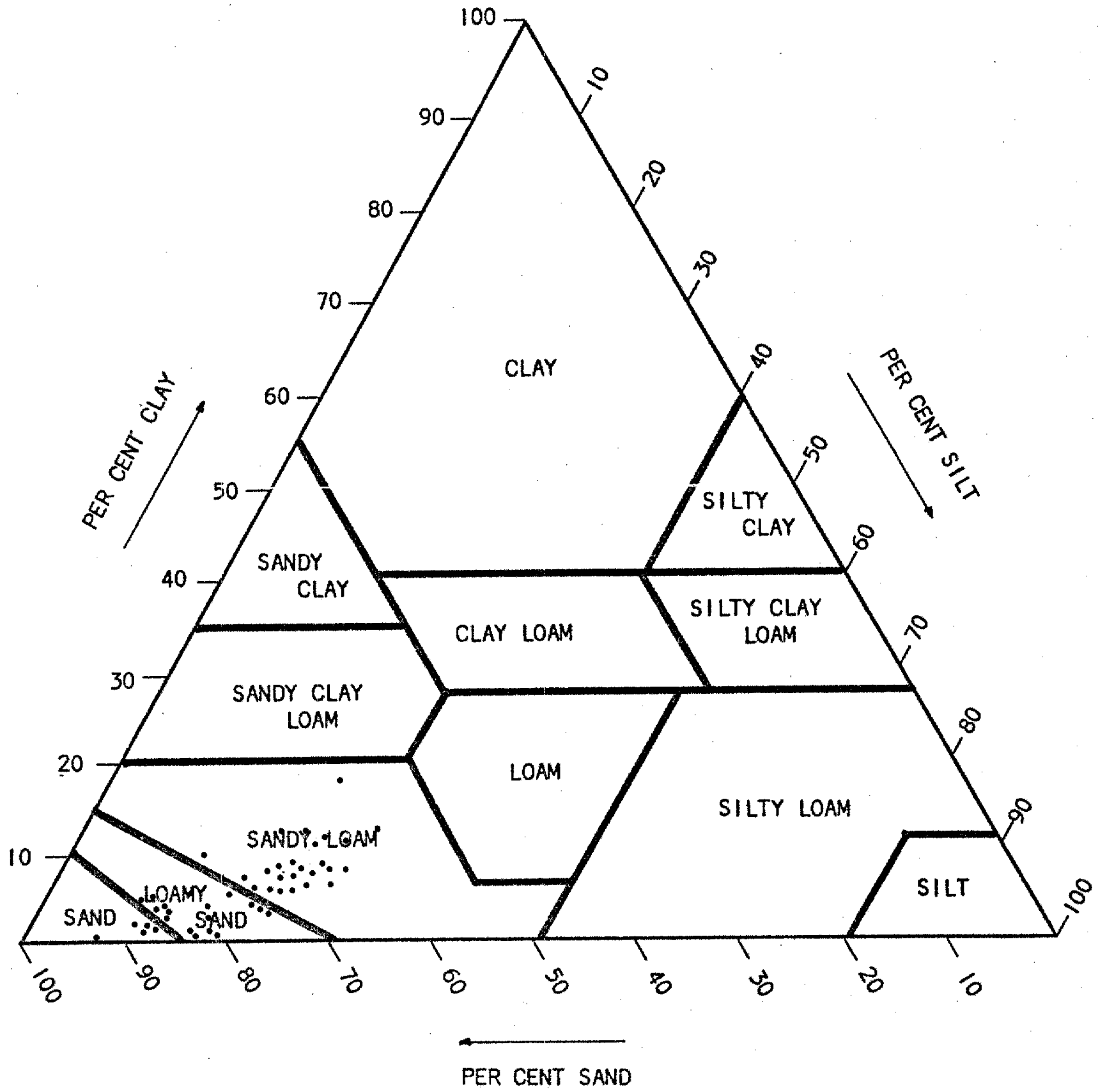


Fig. 8--Soil texture classification distribution in the West Cross Timbers-South in Texas.

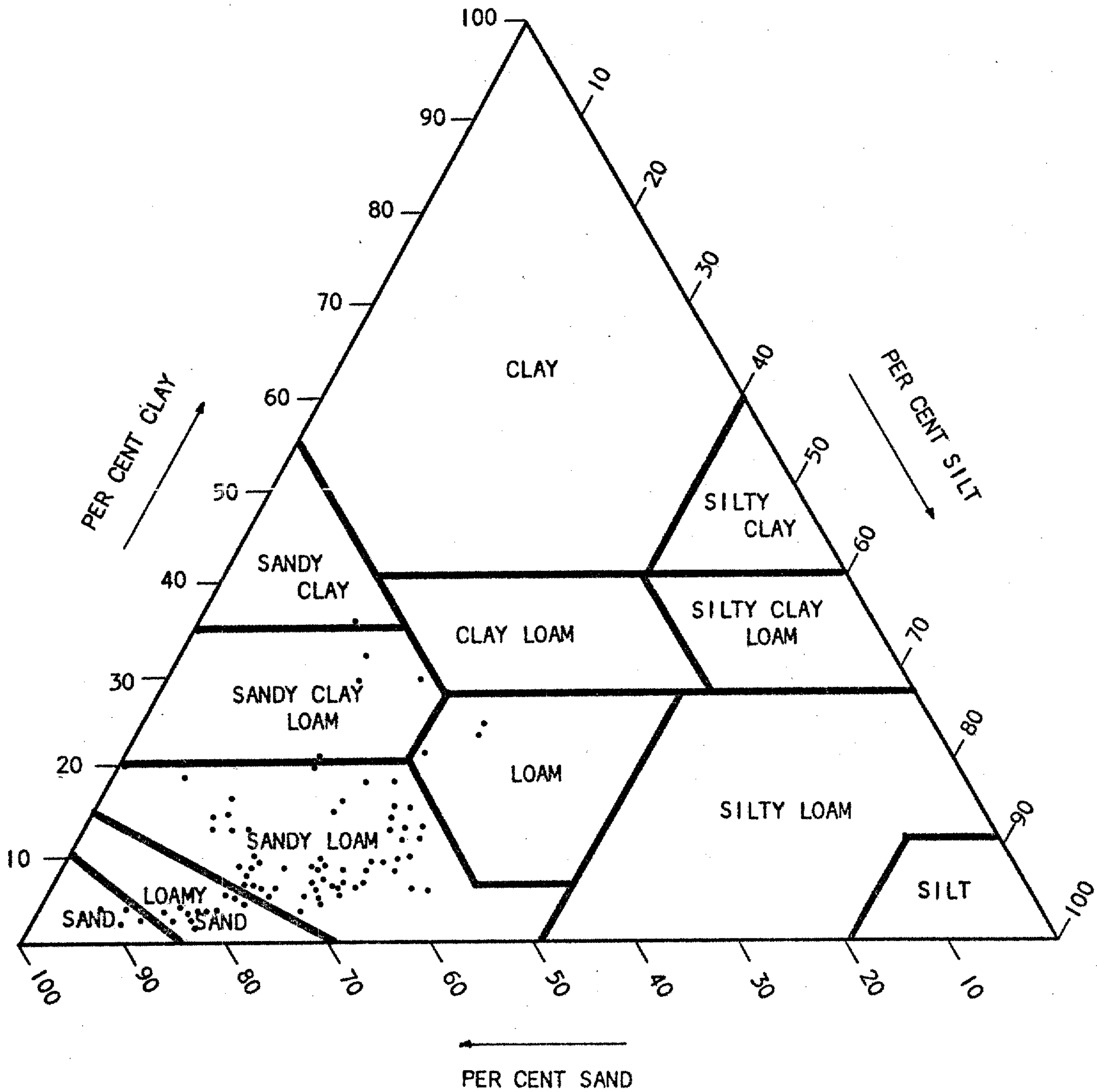


Fig. 9--Soil texture classification distribution in the West Cross Timbers-Central in Texas.

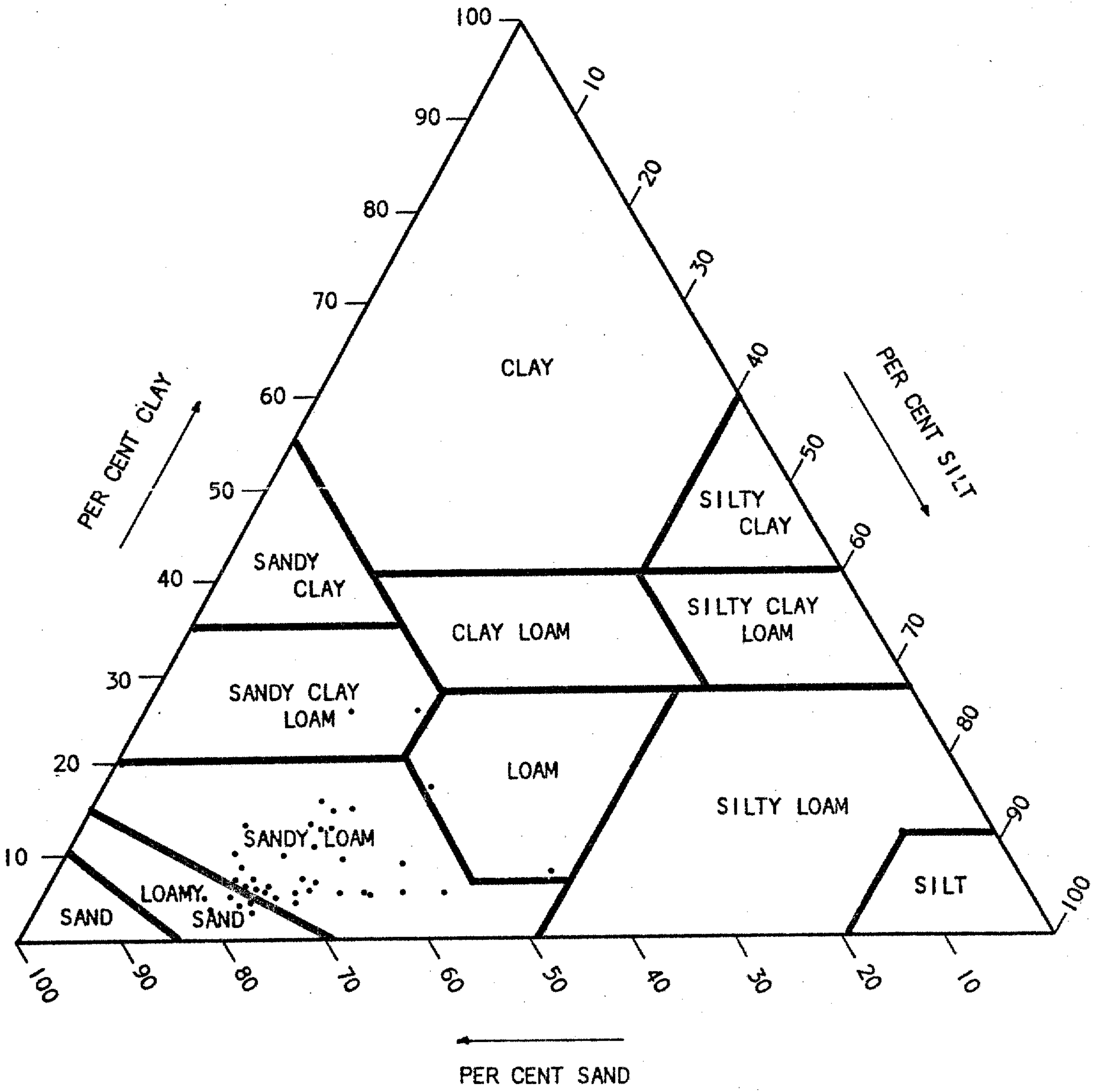


Fig. 10--Soil texture classification distribution in the West Cross Timbers-North in Texas.

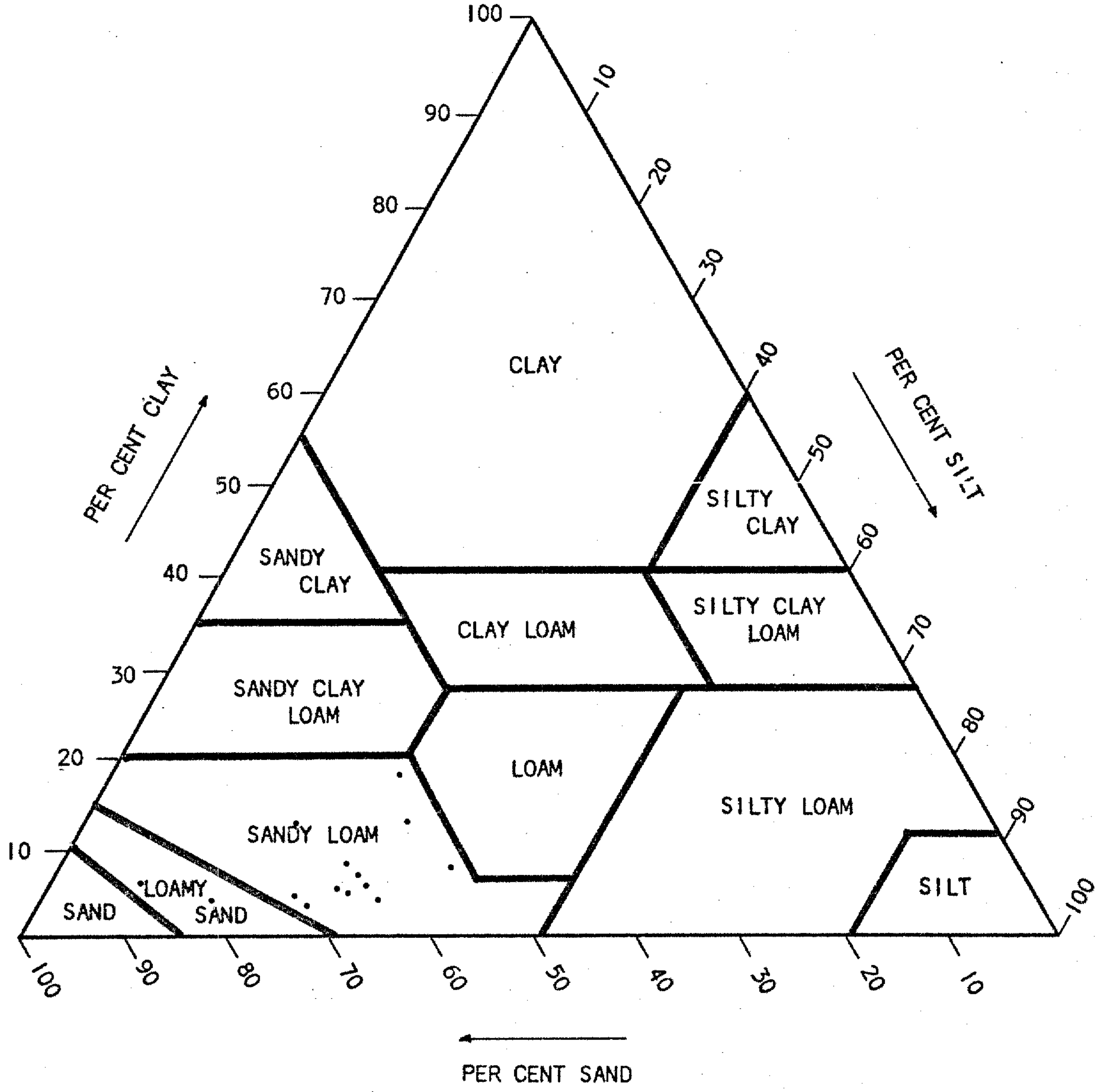


Fig. 11--Soil texture classification distribution in the East Cross Timbers-North in Texas.

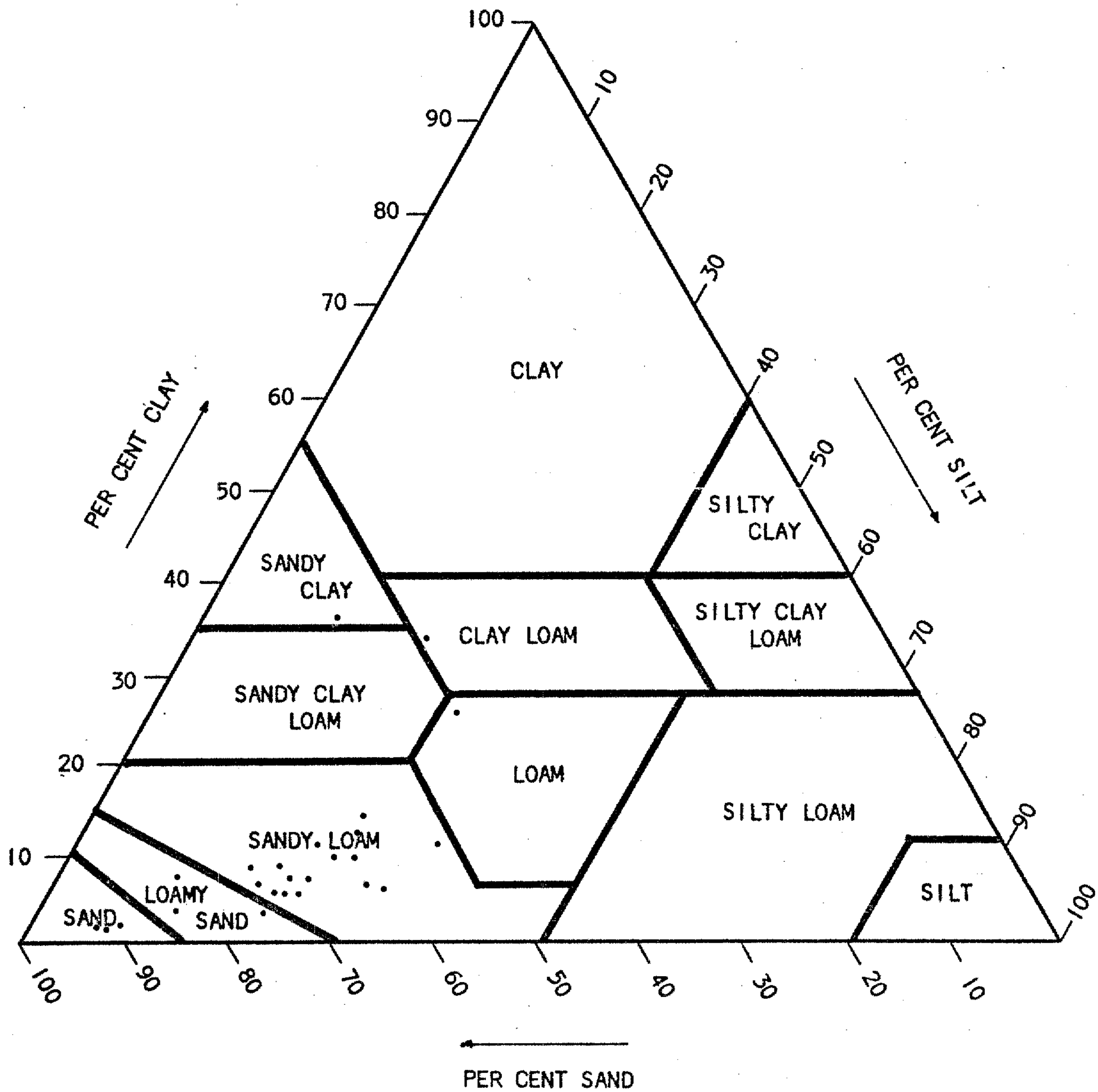


Fig. 12--Soil texture classification distribution in the East Cross Timbers-Central in Texas.

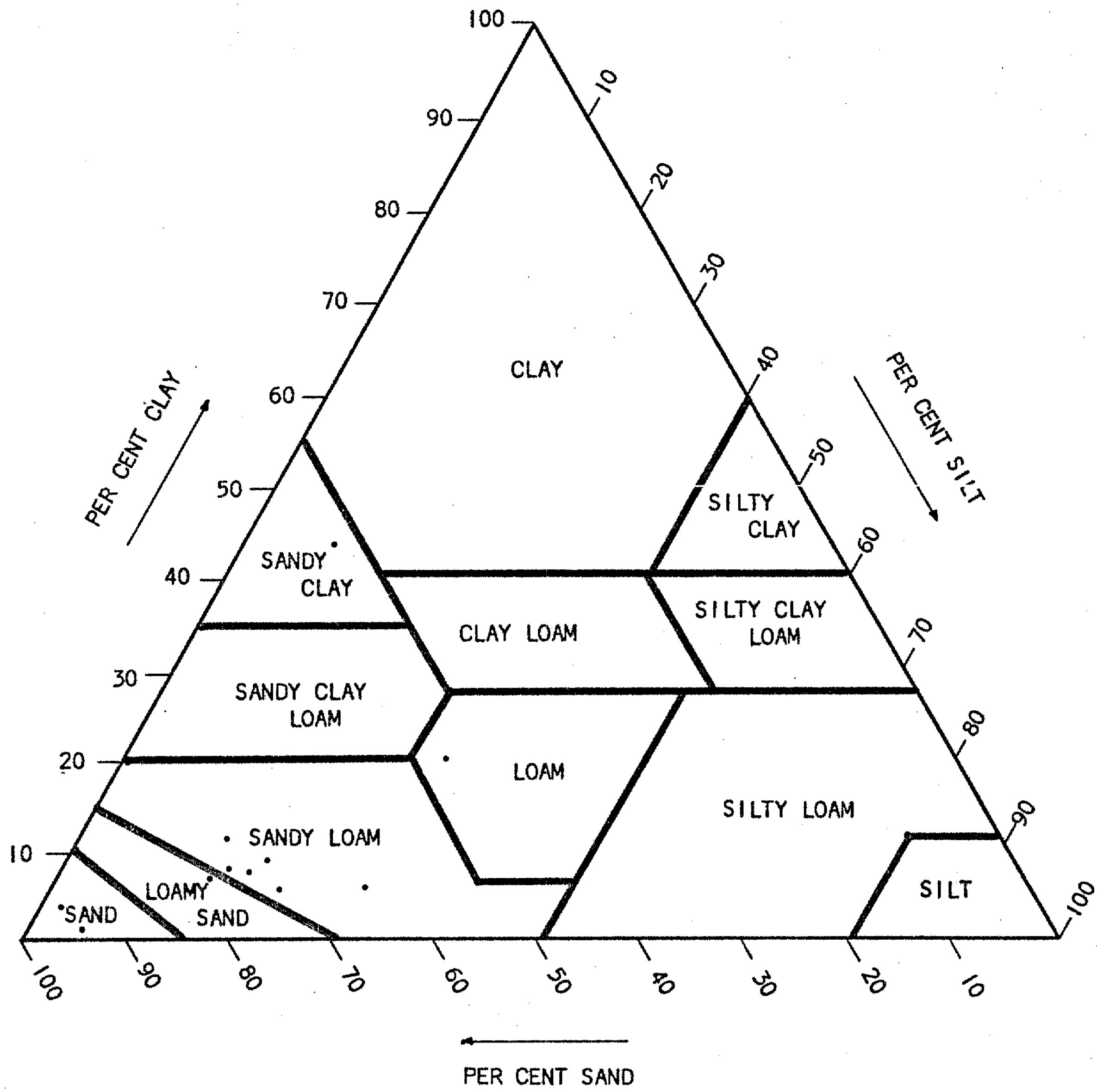


Fig. 13--Soil texture classification distribution in the East Cross Timbers-South in Texas.

TABLE XI

PHENOLOGY OF QUERCUS STELLATA IN THE TEXAS CROSS TIMBERS

	FEB				MAR				APR				MAY				JUN			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
ECTS			+	+	+	X		0	0	0	0	0	0	0	0	F	0	0	0	0
ECTC				+	+	+	X		0	0	0	0	0	0	0	F	0	0	0	0
ECTN						+	+	X		0	0	0	0	0	0	F	0	0	0	0
WCTS				+	+	+	X		0	0	0	0	0	0	0	F	0	0	0	0
WCTC					+	+	+	X		0	0	0	0	0	0	F	0	0	0	0
WCTN						+	+	X		0	0	0	0	0	0	F	0	0	0	0

	JUL				AUG				SEP				OCT				NOV			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
ECTS	0	0	0	0	0	0	0	A	0	0	0	0	0	0	0	0	0	0	0	
ECTC	0	0	0	0	0	0	0	A	0	0	0	0	0	0	0	0	0	0		
ECTN	0	0	0	0	0	0	0	A	0	0	0	0	0	0	0	0	0	0		
WCTS	0	0	0	0	0	0	0	A	0	0	0	0	0	0	0	0	0	0	0	
WCTC	0	0	0	0	0	0	0	A	0	0	0	0	0	0	0	0	0	0		
WCTN	0	0	0	0	0	0	0	A	0	0	0	0	0	0	0	0	0	0		

+ = Bud elongation   X = Bud opening   0 = Leaves in fully-expanded state
F = Fruit appears   A = Fruit begins to drop

The variation in the timing of phenological events was not only observed among the various geographical locations within the Texas Cross Timbers, but variation was also noted on individual trees. Bud elongation, flowering, and leaf expansion all appeared to begin at the tops of the trees and to progress downward to the lower branches (Fig. 14). In the autumn period, the leaves of *Quercus stellata* remained largely intact on the trees for up to three weeks or more after the loss of chlorophyll.

Fig. 14--The expansion of leaves in *Quercus stellata* in the Texas Cross Timbers begins at the top of the tree and progresses downward to the lower branches.

CHAPTER V

DISCUSSION

The observation (Hill, 1887) that the arborescent vegetation was generally larger in the East Cross Timbers of Texas than in the West Cross Timbers was confirmed in this study for *Quercus stellata*. The insignificant difference in the mean density of the reproductive size class (Size A) between the East Cross Timbers and the West Cross Timbers could serve as one indication that the greater amount of grazing in the West Cross Timbers does not greatly affect the post oak seedlings.

In trying to determine the reason for the mean vegetational size differential between the two Cross Timbers areas, it appears that the significantly higher (0.01 level) amount of mean total nitrogen in the East Cross Timbers would have to be considered as a prime factor. While the differences in soil texture between the East and West Cross Timbers were not significant, the East Cross Timbers did have a higher quantity of clay, and this would contribute to a higher nitrogen content (Millar, 1955). One cannot ignore the difference in mean annual rainfall between the two Cross Timbers areas, with the East Cross Timbers receiving nearly ten inches (25.4 cm.) more rainfall per year than does the West Cross Timbers. It has been established (Millar, 1955) that increased soil moisture can contribute to higher soil nitrogen levels. This same correlation was observed in the regional comparisons, with the East Cross Timbers-north and the East Cross Timbers-central showing the highest mean vegetational values along with the highest mean total nitrogen levels. The West Cross Timbers-central showed the lowest mean vegetational values along with a low mean total nitrogen content. The leaf color in the post oaks of the East Cross Timbers was generally a deeper green than that of the leaves in the West Cross Timbers, again revealing the influence of the mean difference in nitrogen levels (Donahue, 1958).

With the exception of per cent frequency, the East Cross Timbers-central showed the highest vegetational values and the West Cross Timbers-central demonstrated the lowest values. In attempting to correlate these extremes with the edaphic values it was noted that potassium showed the highest mean value in the West Cross Timbers-central and the lowest in the East Cross Timbers-central. The lower potassium levels in the East Cross Timbers are probably due to a higher rate of leaching, again, due to higher mean annual rainfall in this area.

The mean total values for magnesium, calcium, and phosphorus were not significantly different between the East and West Cross Timbers and could not be considered as important factors in the differences among the vegetational parameters. In the regional comparisons the East Cross Timbers-south and the West Cross Timbers-north demonstrated significantly higher quantities of mean total phosphorus, but no correlations could be established with mean vegetational or edaphic trends.

In all comparisons, whether area or regional, the mean pH values were at neutral to slightly acid (7.08386 - 6.42667). In both the comparison between the entire East Cross Timbers and the entire West Cross Timbers, and the regional comparisons, the East Cross Timbers showed significantly lower pH values. This, again, can be correlated to the higher mean rainfall rates of the East Cross Timbers as well as to the slightly higher levels of colloids in the East Cross Timbers. The higher rainfall would appear to contribute to the lower pH in its contribution to the leaching of such soil nutrients as potassium, calcium, magnesium, and phosphorus.

In the comparisons of slope effects, the highest mean values for overall density and the reproductive size class were on the east slope. The highest mean values, though, for the D and E size classes and for the mean basal area (biomass) were in the unsloped areas. The unsloped value for mean basal area was, in fact, significantly higher (0.01 level) than all the other areas. While not statistically significant, the mean per cent of total colloids and the mean total nitrogen level were highest for the unsloped areas. There were significant differences in pH according to slope, with the unsloped mean pH value being the lowest. The mean values for total potassium, magnesium, calcium, and phosphorus were highest for the east slope, with some statistically significant (0.05 level) differences being notes for phosphorus. The lowest mean phosphorus value, again, was for the unsloped areas. One reason for the greater mean basal area, higher mean total nitrogen, and lower mean pH could well be greater retention of water, with less runoff than would be the case on the sloped areas.

The influence of the prevailing winds from the Gulf of Mexico would seem to have considerable influence on the phenological events over the Texas Cross Timbers. The mean minimum temperatures over the study area and the timing of the early phenological events are quite parallel. The earliest phenological events of the year probably are under the warming influence of the southerly Gulf breezes, which, of course, would influence the East Cross Timbers-south earlier, due to its geographical location in relation to the Gulf of Mexico, than it would the other regions. There does not appear to be any edaphic influence on the timing of the phenological events from the data collected in this study.

The greater tendency of the post oaks to grow in clumps in the West Cross Timbers as opposed to the East Cross Timbers is one result of more arid conditions in the West Cross Timbers.

Because of the use of the quadrat method to sample the reproductive size class (Size A) and the crown intercept-line transect to sample the other size classes, it is difficult to make any correlation between the reproductives and the other size classes. In comparing the size classes B through E, by far the largest percentage of trees in all regions was in the B size class (4 cm. - 15 cm. dbh) and there were almost no trees in the E size class (42 cm. + dbh) (Figs. 15 and 16). The decreasing density of larger size classes could be indicative of anthropeic intervention in past years during the time when there was a great demand for post oaks for firewood and various other uses. Other explanations could include some type of disease problem in older trees, inability of larger trees to cope with drought conditions, or some genetic limitation; but further observation and analysis are necessary to determine the importance of these potential factors. There is the possibility that the paucity of the larger size classes in the West Cross Timbers is due to a different cause. An extensive study of the annual ring-diameter relationship could lend some light in this area. Because the East Cross Timbers is more heavily populated by human inhabitants, anthropeic intervention is more likely the cause for the absence of the larger size classes.

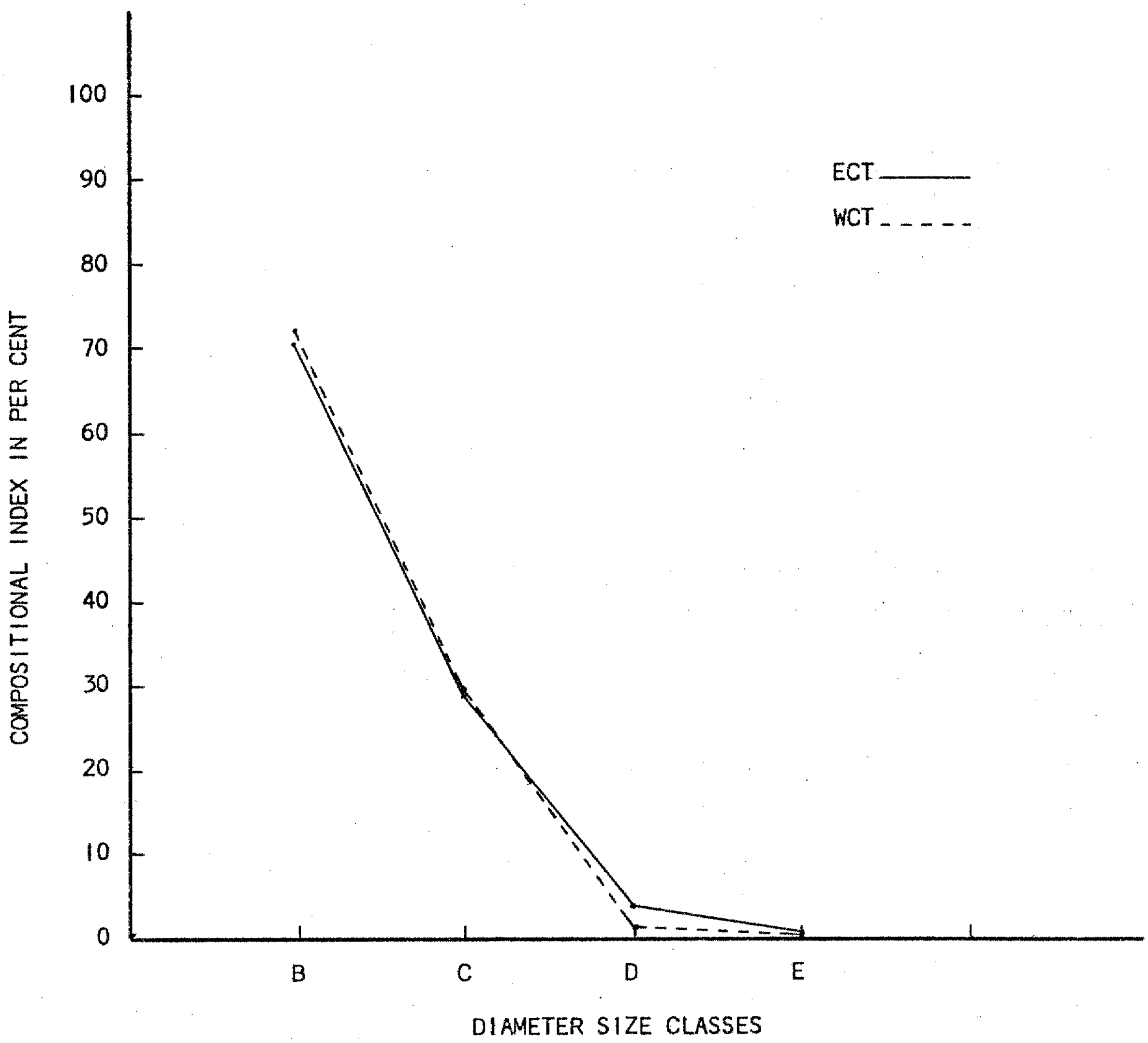


Fig. 15--Compositional profiles for <u>Quercus stellata</u> in the Texas Cross Timbers.

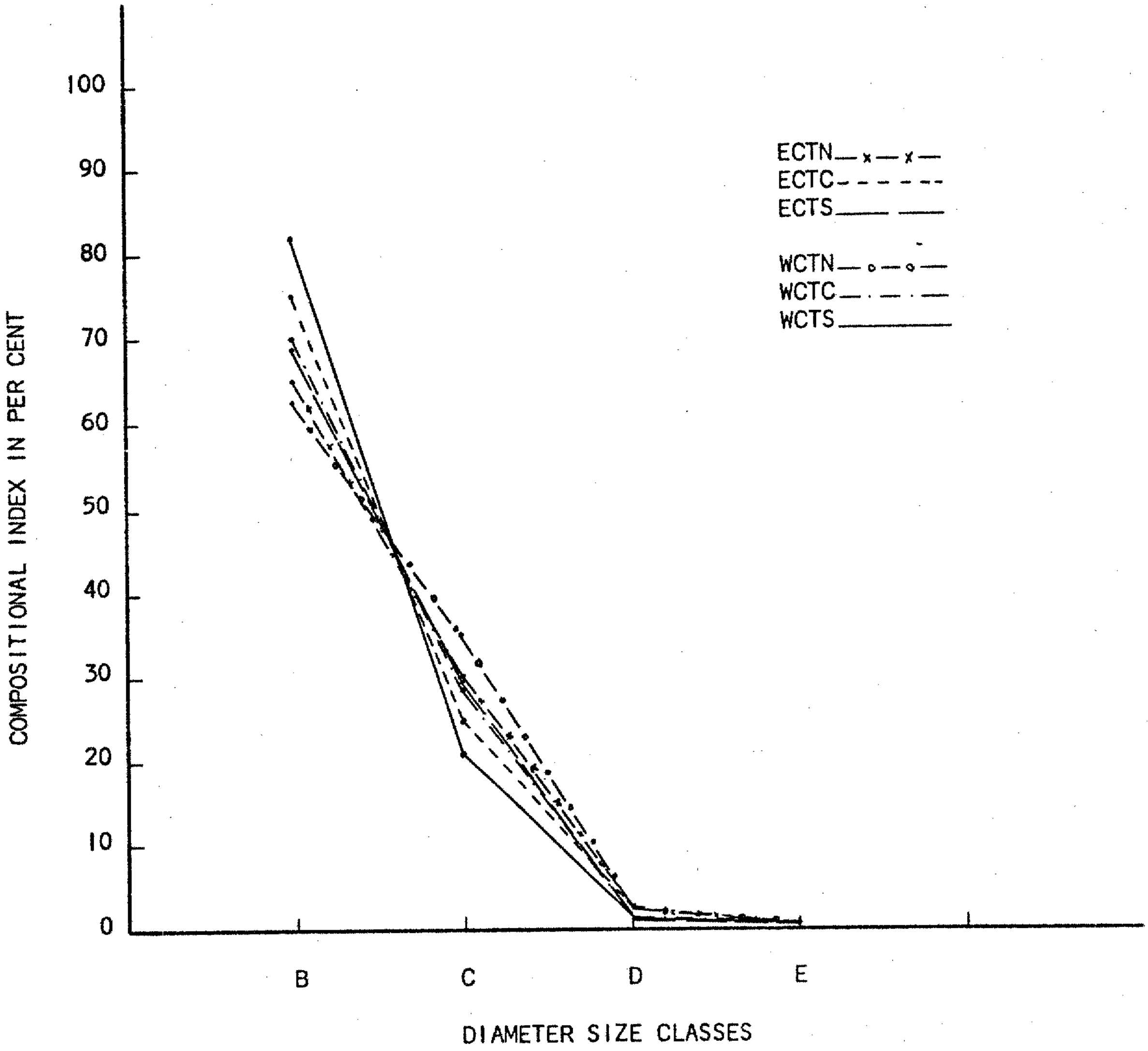


Fig. 16--Compositional profiles for <u>Quercus stellata</u> in the six regions of the Texas Cross Timbers.

CHAPTER VI

CONCLUSIONS

1) The demonstrated vegetational differences between the East Cross Timbers and the West Cross Timbers are apparently not due to any major edaphic differences.

2) The higher basal area and density values of the East Cross Timbers are probably due to higher rainfall than that in the West Cross Timbers.

3) The higher mean rainfall contributes to a higher nitrogen content in the East Cross Timbers, which is probably the direct influence on vegetational size and density differences.

4) The greater mean basal area of unsloped stands is probably due to less water runoff and higher nitrogen content.

5) The higher tendency of *Quercus stellata* to clump in the West Cross Timbers is due to the greater aridity of that area.

6) The phenology of *Quercus stellata* demonstrates the probable influence of climate modification from the Gulf of Mexico.

7) The anthropeic factor is apparently significant in the modification of the post oak population in the Texas Cross Timbers.

8) The general impression is that the non-anthropeic biotic and physical factors are contributing to the continued success of the population of *Quercus stellata*.

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