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THE RELATION OF FOREST VEGETATION TO SOILS AND

GEOLOGY IN THE GULF COASTAL PLAIN IN OKLAHOMA

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

THE RELATION OF FOREST VEGETATION TO SOILS AND GEOLOGY IN THE GULF COASTAL PLAIN IN OKLAHOMA

INTRODUCTION

In Oklahoma it has been noted that certain types of forest grow on soil derived from sandstone or other sandy material, whereas grassland usually develops on soil derived from limestone or clay (Bullard 1926, Bruner 1931, Little 1938, Duck and Fletcher 1945, Gray and Galloway 1959). Various relationships of vegetation types and geological material in Oklahoma are discussed in the following papers: Taylor and Penfound (1961), Buck (1964), Crockett (1964), Dwyer and Santelman (1964), Hall and Carr (1964), Shed and Penfound (1964), and Hutcheson (1965). Geologists have realized the value of differences in types of vegetation in ~~geological~~ mapping (Cuyler 1931). The use of aerial photographs in geological mapping today is a standard practice (Gibbs 1950, Olson 1965). Differences in vegetation may often be related to differences in soil. Rice, Penfound, and Rohrbaugh (1960) found that three species of grass came into revegetating old fields in order of increasing nitrogen and phosphorus requirement. Beals and Cope (1964) found differences in herbaceous vegetation in Indiana forests associated with differences in drainage and soil moisture. Beadle (1966) discussed the role of soil phosphate in the molding of segments of the Australian flora. Mooney (1966) found that a number of soil properties was involved in the altitudinal distribution of two species of *Erigeron*. Porter (1966) found a difference in the distribution of two ecotypes of *Panicum virgatum* associated with a difference in nitrogen requirements.

It is known that soil is influenced by the type of plants that grow on it. The role of certain legumes and a few other plants in increasing soil nitrogen is well decumented. Eyre (1963) notes that quite different soil may develop under grasslands than under forest, even when the two areas lie side by side. Braun (1964) discussed the difference in color and texture in some islands of prairie soil that are surrounded by forest. Zinke (1962) found differences in soil under individual forest trees.

Thompson (1952) states that a soil is the product of the interaction of parent material, climate, vegetation, topography, and time. Only a few studies that have dealt with the relationships between vegetation and geological material in Oklahoma have involved soil analysis. In this study the vegetation of 13 forest communities was analyzed. These communities are located in the Bryan County portion of the Gulf Coastal plain of southeastern Oklahoma. The soil in which they grew was analyzed and the communities were correlated with soil and geological material.

The geological formations of the old Cretaceous Gulf Coastal Plain are composed mainly of sandstone, limestone, and clays that lie parallel and generally running east and west throughout the area. Since much of the area is forested, it provides an excellent location for study of forest types and soils on different geological material.

Only communities growing on relatively level land and on soil derived from a particular recognizable geological formation were used. Ten upland and three bottomland communities were selected for investigation. These communities were located on Antlers sand (previously known as Paluxy sand of the Trinity Group (Forgotson 1957, and Redman 1964), Pawpaw sand, Woodbine sand, Weno formation, Goodland limestone, Duck Creek limestone, Bennington limestone, Kiamichi clay, and Quaternary alluvium from the floodplains of two streams.

The vegetation analysis included the following data on 1) trees, 2) seedlings and saplings, 3) shrubs and vines: mean area, frequency, density, size class, basal area, and plants per acre. The soil properties studied included the following: soil texture, pH, organic carbon content, organic matter, total nitrogen, total phosphorus, volume-weight, and soil color.

The 13 communities enable comparison of 1) communities growing on soils derived from sandstone, limestone, clay, and alluvium; 2) two different stages of succession on alluvium soil (Red River communities); 3) alluvial soil from two stream systems; and 4) communities growing approximately 40 miles apart on the same formations (Pawpaw and Woodbine sands).

LOCATION OF STANDS

The plant communities will hereinafter be referred to as stands. They will be identified by the geological formation on which they grow or stream system in which they occurred. These substrata, together with the stands thereon, are listed below.

Clear Boggy Creek Alluvium

This stand is located approximately 8.5 miles northeast of Bennington in Sec. 8, T5S-R13E.

Red River Alluvium

There are two stands located on the Red River floodplain. One stand is in an early stage of succession, the other is mature. They will be referred to as the Young and Old Red River stands, respectively. The Young Red River stand is located in Sec. 22, T8S-R11E, approximately three miles southeast of Albany. The Old Red River is located approximately 14.5 miles southeast of Bennington in Sec. 17, T8S-R14E.

Antlers Sand

This stand is located in Sec. 8, T5S-R13E, approximately 9.5 miles northeast of Bennington,

Pawpaw Sand

There are two stands located on this formation. They will be referred to as Pawpaw east and Pawpaw west. The Pawpaw east stand is located in Sec. 12, T6S-R12E, approximately 4.5 miles northeast of Bennington. Pawpaw west is located in Sec. 5, T6S-R8E, approximately 2.5 miles northwest of Silo.

Woodbine Sand

There are also two stands on this formation and the same procedure in referring to them will be followed as those of the Pawpaw sand. The Woodbine east stand is located in Sec. 5, T7S-R13E, approximately five miles southeast of Bennington. The western stand is located in Sec. 1, T7S-R7E, approximately two miles southwest of Mead.

Weno Formation

The Weno formation stand is located in Sec. 11, T5S-R7E, approximately four miles northwest of Mead.

Goodland Limestone

This stand is located in Sec. 7, T5S-R13E, approximately nine miles northeast of Bennington.

Bennington Limestone

This stand is located in Sec. 14, T6S-R12E, approximately two miles northeast of Bennington.

Duck Creek Limestone

The Duck Creek stand is located approximately seven miles northwest of Armstrong in Sec. 5, T5S-R9E.

Kiamichi Clay

This last stand is located in Sec. 8, T5S-R9E, approximately 6.5 miles northwest of Armstrong.

The location of the stands and the geology of the study area are shown in Fig. 1. This map is adapted mainly from Miser (1954) and Olson (1965).

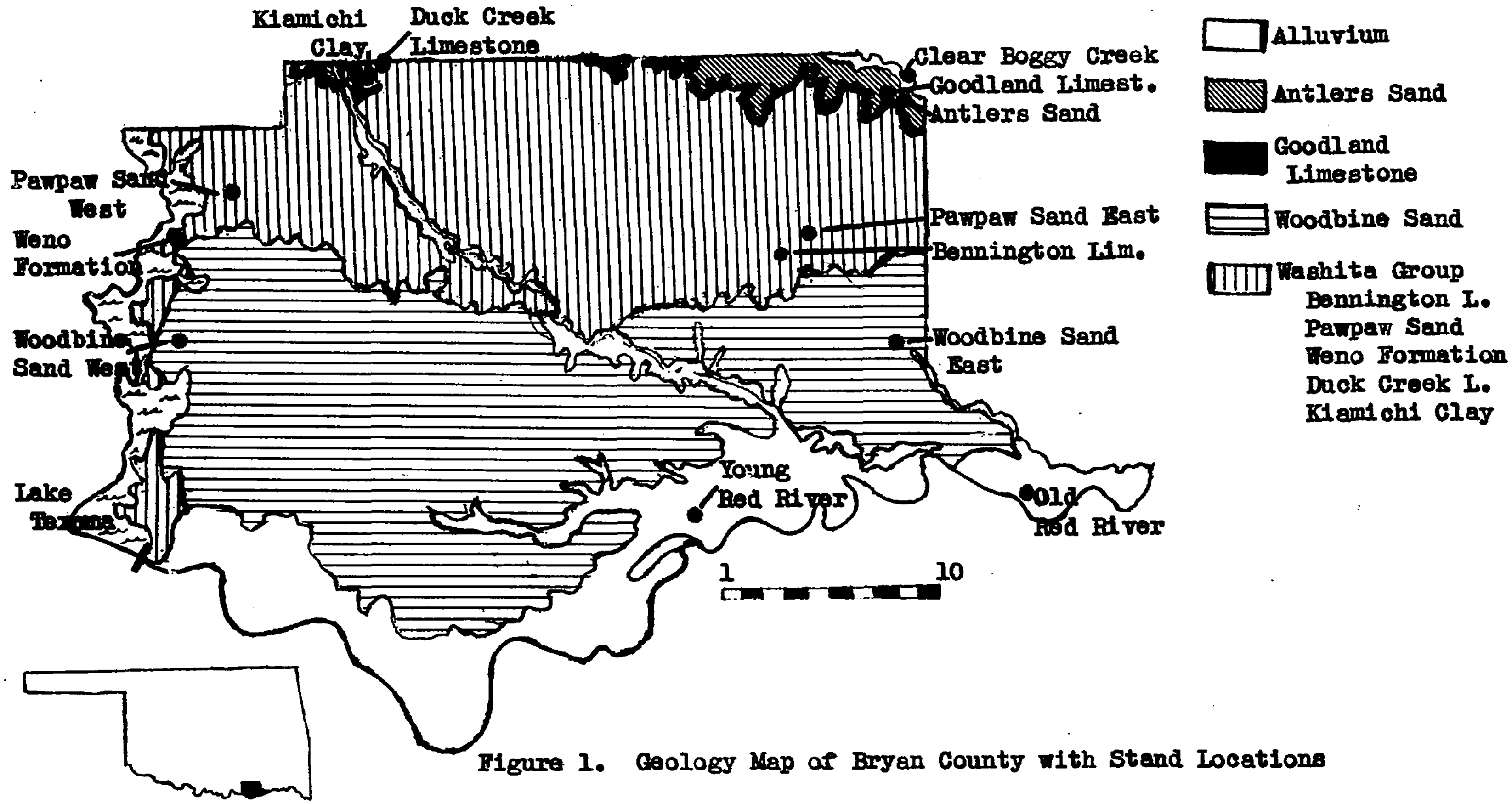

Figure 1. Geology Map of Bryan County with Stand Locations

DESCRIPTION OF AREA

The Gulf Coastal plain of Oklahoma is located in the northwest portion of the Gulf Coastal Plain province of Fenneman (1938). It is an area that extends from the Arkansas border westward to western Love County. The maximum north to south distance is slightly over 35 miles. The main settlement of the area took place in 1832 when the tribes of the Choctaw indians were resettled in this part of the state. Later, from 1834 to 1837, the Chickasaws were also resettled in this area. Continuous cultivation thus dates from this time or slightly earlier.

The coastal plain of Oklahoma is mainly forested, except for occasional strips of grassland mainly along the northern portion becoming predominantly grassland in the western portion. Bruner (1931) classed the eastern half of the area as composed of an oak-hickory association, but oak-hickory savanna was the important type of vegetation in the western portion. Blair and Hubbell (1938) placed most of this area in their Osage Savanna grassland and allied it with the central part of the state. Duck and Fletcher (1945) listed approximately 3600 square miles of forest and only about 800 square miles of grassland for the Oklahoma Coastal Plain area. Their forested areas contain five different types: loblolly pine, oak-pine, oak-hickory, post oak-blackjack oak, and bottomland. Braun (1964) refers to this area as a forest prairie transition area. Rice and Penfound (1959) found post oak, blackjack oak and black hickory to be the most important woody species in the coastal plain area. Kuchler (1964) mapped the potential vegetation as oak-hickory-pine, oak-hickory, cross timbers, bluestem prairie, and the southern floodplain forest. The vegetation of this area like most areas in the state, has been subjected to fire and to the influence of various kinds of agricultural practices since at least 1832.

Climate

The study area has a moist subhumid climate (Thornthwaite 1948). The average annual precipitation ranges from 36 inches in the southwest to slightly over 40 inches in the east (U. S. Dept. Agric. 1941). The average annual snowfall is 2.4 inches. Rainfall is relatively evenly distributed through the year with April, May, June, and July receiving heaviest amounts (Table I). The average annual temperature is 63.4° F. with an average of 83° F. in July and a low of 42° F. in January. Frost free days are from about March 25 to November 5, giving the county a growing season of about 230 days.

Topography

In Oklahoma, the Gulf Coastal plain is characterized by low, eroded, gently rolling hills. Local relief is generally less than 100 feet. There are also extensive areas of slightly undulating surface, which are found mainly in the more northern portion. Elevation of the study area ranges from approximately 750 feet in the north to slightly less than 450 feet in the southeast. Resistant strata form northward-

Table I. Mean precipitation and temperature based on 57 to 60 years of weather data.

Month	Average Monthly Precipitation In Inches	Average Monthly Temperature ° F.
January	2.24	42.4
February	2.59	45.9
March	2.87	54.6
April	4.52	63.0
May	5.40	70.5
June	3.75	79.0
July	3.21	83.0
August	2.75	83.2
September	3.03	76.3
October	3.77	65.2
November	2.62	53.2
December	2.62	44.3
Yearly Average	39.37	63.4

Data from U. S. Department of Commerce, Weather Bureau, Climantography of the United States No. 86-30. 1965. Durant SE State College Station.

facing escarpments with gentle dip slopes toward the south. One of these forms the ridge that crossed the county, in an east-west direction, near the middle of the study area. A second escarpment has been formed along the contact of the Goodland limestone and the Antlers sand. In general the study area slopes from north to south. The drainage pattern is essentially dendritic, reflecting the relative uniform nature of the bedrock and lack of structural control. The area is drained principally by Island Bayou, Blue River, and White Grass Creek into the Red River. The northeast portion is drained by Clear Boggy Creek. Several small streams along the western part drain into the Washita arm of Lake Texoma. Extensive, relatively level floodplains are found along most of the rivers. Along some streams, natural levees have developed so that the portions of the floodplain farthest from the streams are lowest. As a result, during rainy periods these floodplains are inundated and wet for long periods. This has produced extensive swampy bottomland type of forest in many places. Minor topographical features of the area include benchlike terraces which are found mainly along the Red River. At various places there are high-level terrace remnants, presumably early Pleistocene in origin. The controversial pimple mounds (Melton, 1954) are found in many places throughout the coastal plain with some in the immediate area of the study stands. Another feature which none of the geologists who have worked here have discussed, are the hillside seeps or bogs (Taylor and Taylor 1965). .

Geology

Except for quaternary alluvium, only Cretaceous formations of the Comanchean and Gulfian series are recognized as occurring at the surface in the study area. At present no detailed geological study exists that covers all of it. The northern part was studied and mapped by Taff (1902, 1903). The region mapped by Stephenson (1919) covers the southeastern portion of the study area. The legend of the Geologic Map of Oklahoma (Miser 1954) contains much information about geological studies done here. Hedlund (1962) studied the Red branch member of the Woodbine formation. Recently a very fine study has been completed covering a large portion of Bryan County (Olson 1965). All but five of the stands and all geological formations of this study lie within the area of his investigation.

A number of other investigations have dealt with Cretaceous and Quaternary geology of the Gulf Coastal Plain of southeastern Oklahoma. Some of these are listed: Love County (Bullard 1925); Marshall County (Bullard 1926); Choctaw County (Gibbs 1950); McCurtain County (Heilborn 1949, Skolnick 1949, and Davis 1960); Lower Cretaceous(Miser 1927); Trinity Group (Vanderpool 1928); Woodbine formation (Curtis 1960); and the Goodland Limestone (Blau 1961).

Stratigraphy

The Cretaceous formations occurring at the surface in the study area are considered to belong to two series, the Comanchean and Gulfian. The oldest, the Comanchean, has been further divided into three groups. Oldest to youngest, they are the Trinity, Fredericksburg, and Washita. A generalized columnar representation of the geological material found at the surface in the study area is shown in Figure 2. This columnar section is adapted mainly from Olson (1965).

<u>Antlers Sand</u> This formation consists of approximately 300 feet of loosely consolidated white to yellow crossbedded pack sand interbedded with clay and sandy clay. At places there are moderately indurated layers of iron-cemented sandstone up to 3 feet thick. The soil formed from this material is generally a sandy or sandy loam with grayish brown surface and yellowish sand clay loam subsoil. Forest vegetation usually develops on soil from this formation.

<u>Goodland Limestone</u> This is a compact, finely crystalline limestone that becomes nodular near the bottom. Since it overlies the easily eroded Antlers Sand, a low escarpment forms along their contact. This limestone is about 20 feet thick in the study area. The soil formed from the Goodland is shallow clay to sandy clay loam, reddish black to dark reddish brown, only slightly differentiated in the lower portion. Several types of vegetation develop on this formation ranging from grassland to forest.

<u>Kiamichi Clay</u> This is mainly a black, shaly clay which is thinly bedded with iron-stained laminae. The upper portion is a hard yellowish-brown oyster shell limestone, large slabs of which break off as a result of slumping of the soft underlying clays, forming what is sometimes referred to as edgerock soils. This formation is about 35 feet thick. The soils that develop from the Kiamichi material consist of brown to dark brown clay at the surface with yellowish brown to brown clay subsoils. Grassland is the usual vegetation developing on this soil, but forest may be encountered.

Age	Series	Group	Formation
Recent			Mainly Alluvium
Pleistocene			Terrace and Alluvium
Cretaceous	Gulfian		Eagle Ford Shale Woodbine Formation
	Comanchean	Washita	Bennington Limestone Pawpaw Sand Weno Formation Denton Clay Fort Worth Limestone Duck Creek Limestone
		Fredericksburg	Kiamichi Clay Goodland Limestone
		Trinity	Antlers Sand

Figure 2. A generalized columnar representation of the geological material found at the surface in the study area.

Duck Creek Limestone This consists of approximately 100 feet of interbedded, soft, cream-colored limestone and bluish-gray, shaly clay. The soil that develops on this formation is a very dark gray clay at the surface with dark gray calcarous subsoil. The soil of the study stand was very shallow with limestone rock at the surface in many places. Grassland is the usual vegetation on this soil, but a weedy forest may develop.

Weno Formation This formation consists of ferruginous sandstone, brownish marls, marly clays, and impure limestone. It was about 100 feet thick in the study area. The soil had a yellowish-brown to grayish-brown sandy loam surface with a yellow red sandy clay loam subsurface. In the study area its appearence at the surface was very similar to that of the Pawpaw sand which lay above it. Sometimes it is very difficult to distinguish between the two formations. The vegetation is often similar in appearence with no discernible break at their contact. However, their contact is usually marked by a thin limestone ledge, the quarry limestone, which occurs in the upper portion of the Weno.

Pawpaw Sand The Pawpaw sand is composed mainly of yellow to red ferruginous sand interbedded with yellow to gray sandy clay and is about 50 feet in depth. The soil formed is essentially like that of the Weno, being somewhat more sandy and more grayish brown in the surface soil. Forest is the usual vegetation in this area.

Bennington Limestone This formation consists of from 10 to 20 feet of hard, brownish-yellow, crystalline limestone. Olson (1965) listed only seven feet of it for eastern Bryan County. The soil of the forest stand located on this formation is a shallow dark brown loam only slightly differentiated in the lower portion. Limestone rock occurrs.at the surface in many places. An open, weedy, scrubby forest type of vegetation developed.

Woodbine Formation This formation is composed of a series of red to tan moderately-indurated, ferruginous sands interbedded with silty clays and carbonaceous shale. It is somewhat over 300 feet thick. The soil that developed in the study area is very much like that of the Pawpaw sand and usually supports forest vegetation.

Alluvium The alluvium studied was of two distinct types as indicated by the differences in soils and in types of vegetation. The soils of the two Red River floodplains stands were similar, whereas the soil of the Clear Boggy Creek stand was quite different. The soil of the Clear Boggy alluvium has a very dark gray clay at the surface with a slightly lighter gray clay subsoil. The soils of the Red River stands exhibit a reddish-brown clay in the surface soil with reddish sandy loam in the subsoil. In some places, the subsoil has areas of clay several inches thick, but in other areas, it consists of almost pure sand. The types of vegetation supported by the two types of alluvium are bottomland forests.

Soil Types

The soil types mapped for the area of each stand were taken from the field data of Mr. Carter Steere, Soil Conservation Service.

The U. S. Department of Agriculture is conducting a new soil survey of Bryan County.

The soil type of the stands on the Antlers Sand, Pawpaw Sand East, and Woodbine Sand East are in the Bowie series. The Pawpaw Sand West, Woodbine Sand West, and Weno Formation soil types are in the Ruston series, which is very similar to the Bowie. The two Red River alluvium stands includes soils of the Yahola series. The soil type mapped for the area of the Clear Boggy Bottom stand is in the Osage series, which is similar to the Kaufman series. The type of the Goodland Limestone stand is in the Claremore series, which is somewhat like the Newtonia series. The soil type of the Bennington Limestone stand is in the Hunt series, whereas that of the Duck Creek is in the San Saba series. The Kiamichi clay stand includes soil of the Denton edgerock series.

METHODS

The first stages of this study involved extensive reconnaissance in an attempt to become familiar with the different types of woody vegetation found in the coastal plain portion of Oklahoma, but became centered in the Bryan County area. Geological formations underlying various kinds of forest stands were studied to ascertain what type stands might be expected to occur on the different formations. Eventually. 13 stands located within an area approximately 25 miles north to south by 40 miles east to west were selected for further study. This area was selected because more extensive exposures of the Gulf Coastal Plain formations that are forested are found here. Care was taken to select stands as mature as possible and well within the area of outcrop of a particular formation. Only stands large enough to permit a satisfactory sample, approximately 40 acres, were utilized.

The point-centered quarter method was used to obtain data for the vegetation analysis. This method was described and tested by Cottam and Curtis (1956). They found that of the types of distance methods commonly used in forest vegetation analysis, the quarter method gives least variable results for distance determinations, provides more data on tree species per sampling point, and is least susceptible to subjective bias. In this method a series of points were established at predetermined intervals along a transect. The distance to the nearest individual in each of the four quadrants was then determined. The transects were placed in such a manner that the points were distributed throughout a stand. A total of 25 points (100 quadrants) at 20 pace intervals were taken in each stand. The species and the d.b.h. (diameter at breast height) for each tree was then listed. D.b.h. was used to compute basal area for each species and total basal area for the stand. The distances to the nearest individuals were averaged to obtain the mean distance. The mean of all the distances obtained from one stand (mean distance) has empirically (Cottam, Curtis, and Hale 1953) and theoretically (Morisita 1954) been shown to be equal to the square root of the mean area per plant. By dividing 43,560 square feet by the mean area per plant, the number of plants per acre was derived. The mean area and plants per acre for trees, seedlings-saplings, and shrubs-vines, was computed in this manner. The number of points at which a species was encountered divided by the total number of points times 100 was used to obtain species frequency within a stand. The density of a species was determined by taking the number of a species tallied for a stand divided by the number of samples times 100. Mean area, number of plants per acre, and mean distance are all related to density. The relative values for frequency, density, and basal area or dominance were computed by the formulas below.

$$\text{Relative frequency} = \frac{\text{frequency of a species}}{\text{total frequency of all species}} \times 100$$

$$\text{Relative density} = \frac{\text{Density of a species}}{\text{total density of all species}} \times 100$$

$$\text{Relative basal area} = \frac{\text{basal area of a species}}{\text{total basal area of all species}} \times 100$$

Importance percentage of trees was obtained by adding relative frequency, relative density, and relative basal area, then dividing by three. Importance percentage of seedlings-saplings and shrubs-vines was obtained by averaging relative frequency and relative density. Approximately 2,000 specimens of vascular plants have been collected from the study area including at least one specimen of each of the species discussed. All are now deposited in the Bebb Herbarium, University of Oklahoma, in Norman.

Soil samples were taken from 0-6 inches at 10 stations in each area. Only the 0-6 inch layer of soil was sampled as soil covering most of the limestone was so shallow that it was difficult to sample even to this depth in many places. The stations were chosen in such a manner as to be evenly distributed. A soil auger was used to collect the samples. Care was taken to remove all of the duff before collecting samples, and all soil from one area was placed in a single container. The soil was then thoroughly mixed, air dried, sifted through a 2 mm. sieve, and stored in a stoppered container. A portion from each of the composite samples was oven dried at 105° C. for 48 hours to obtain the moisture content. All determinations that involved specific quantities of soil are based on oven-dry conditions. After soil reaction (pH) and soil texture were determined, the remaining portions of each composite sample were ground through a soil mill and stored for further analysis. Soil reaction was determined by a Beckman glass electrode pH meter. A method modified from Bouyoucus (1936) was used for determination of soil texture. Determination of organic carbon was by the method outlined by Piper (1944). The method used for determination of total phosphorus was modified from Shelton and Harper (1941). Total nitrogen was determined by the method of Noggle and Wynd (1941). All of these determinations were run in duplicate. If the values for the two samples were essentially the same, they were averaged and this value used. If the two samples varied more than a few points, additional samples were analyzed. Volume-weight (soil compaction) was determined by the following method. Ten holes per stand, approximately 2 inches in diameter and 3 inches deep were excavated. The soil from each hole was collected and later oven dried. Then each hole was filled with oven-dry quartz sand and the volume recorded. Later oven-dry weight of the collected soil was determined, and compaction was calculated by dividing this weight in grams by the cubic centimeters of sand. The air dry color of each soil sample was determined with the aid of a Munsell Color Chart.

RESULTS

Vegetation and Soil Relationships in Individual Stands

Clear Boggy Creek Stand

The vegetation of this stand was an open elm-ash-hackberry community. It is not typical of this type in Oklahoma, as the species of elm was neither *Ulmus americana* (Nomenclature after Waterfall 1966) nor *U. rubra*, but *U. crassifolia* (Table II). It was the most open stand, but had next to highest basal area per acre, 104 sq. ft. The average d.b.h. of the stand was 11.0 inches (Table III). Although this type of community occurred in a number of places elsewhere in the Gulf coastal plain in Oklahoma, especially in the western part, it does not seem to have been previously described for the state. This stand corresponded to cover type 85 of the Society of American Foresters (1931). All further cover types mentioned are from this source. Seedlings and saplings indicate that green ash and hackberry were becoming increasingly important, whereas there were only a few seedlings of *U. crassifolia* (Table IV). *Ilex decidua* was the most common shrub, and *Campsis radicans*, *Parthenocissus quinquefolia*, and *Vitis* spp. were the most common vines (Table V).

The soil of this stand was a dark-gray, moderately alkaline clay. The pH of 8 was the highest soil reaction for any stand of this study (Table VI). The soil was rather high in phosphorus,

Table II Importance percentage of trees in the 13 forest stands studied. An x represents a value of less than 5 per cent.

Species	BB	OR	YR	A	WE	WW	PE	PW	WF	GL	BL	DC	KC
Ulmus crassifolia	26									x		67	75
Celtis spp.	27	35								x	34	x	
Fraxinus pennsylvanica	25	19	11	x									
Maclura pomifera	8		x	x						6	27	25	25
Quercus phellos	9												
Q. nigra	x												
Q. macrocarpa	x												
Ulmus rubra	x	35											
Crataegus spp.	x						x				x		
Carya illinoensis		x	x										
Acer negundo		x	x										
Diospyros virginiana		x			x								
Gleditsia triacanthos		x		x	x						11	x	
Morus rubra		x	x			x				x			
Platanus occidentalis		x											
Populus deltoides			74										
Salix nigra		x	7										
Carya texana				37	9	16	42	31	x	29			
Quercus stellata				27	38	45	17	30	68	20			
Q. velutina				13	13	21	13	11		x			
Q. falcata				x	17		x			9			
Q. marilandica				x	x	12	10	19		x			
Ulmus alata				x	10	x	5	7	13	x	16		
Cercis canadensis				x				x		x			
Ulmus americana				x		x		x			x		
Carya tomentosa				x	x		8			x			
Fraxinus americana									17	5	x		
Quercus shumardii									x	8	x		
Bumelia lanuginosa										x	x	x	
Q. muehlenbergii										x			
Prunus spp.										x			
Q. rubra				x									

BB - Boggy Creek Bottomland
OR - Old Red River Alluvium
YR - Young Red River Alluvium
A - Antlers Sand
WE - Woodbine East
WW - Woodbine West
PE - Pawpaw East
PW - Pawpaw West
WF - Weno Formation
GL - Goodland Limestone
BL - Bennington Limestone
DC - Duck Creek Limestone
KC - Kiamichi Clay

Figure 3. Clear Boggy Creek Stand

Figure 4. Antlers Sand Stand

Table III Number of woody plants, basal area, and d.b.h. of trees in the forest stands investigated.

Stands	Trees per Acre	Mean d.b.h. in inches	BA/Acre in sq. ft.	Seedlings, Saplings, per Acre	Shrubs, Vines, per Acre
Bottomland Stands					
Clear Boggy Creek	111.2	11.91	104.2	2,807	105
Red River Alluvium					
Young Stand	112.6	8.45	51.7	144	3,457
Old Stand	190.0	10.53	142.5	358	3,723
Upland Stands					
Sandstone Formations					
Antlers Sand	244.8	7.32	88.7	6,396	7,169
Woodbine East	171.0	8.90	90.3	6,443	5,556
Woodbine West	254.6	6.69	75.3	1,308	8,377
Pawpaw East	240.4	6.13	65.7	4,229	3,556
Pawpaw West	160.4	8.40	81.9	8,677	3,704
Weno Formation	245.1	6.10	61.6	2,774	3,723
Limestone and Clays					
Goodland L.	277.5	6.76	85.1	9,248	2,074
Bennington L.	235.2	6.82	86.8	1,571	259
Duck Creek L.	173.0	5.09	26.0	486	-
Kiamichi Clay	265.4	5.68	62.4	563	511
Stands Average	206.3	7.59	78.6		

nitrogen, and organic carbon. Since it was often inundated for extended periods each year, there were several layers of dark-gray black sediment.

Young Red River Stand

This stand was composed primarily of *Populus deltoides*, and corresponds to forest type 61 (Table II). It usually succeds *Salix nigra* and *S. interior*, and is followed by green ash, species of elm, and hackberry. Of all stands, it had next to the lowest basal area per acre (54 sq. ft.) and was one of the most open stands (Table III). The mean d.b.h. for this stand was 8.5 inches. The number of seedlings and saplings indicated that *Fraxinus pennsylvanica* has already become an important member although black willow still persisted. Reproduction was largely by black willow, but a number of green ash, red mulberry, eastern red cedar, and an occasional american elm forcastes a change to an elm-ash-hackberry community (Table IV). *Cornus drummondii* formed an important part of the understory with *Rubus* spp. and *Rhus toxicodendron* being the main vines (Table V).

The soil was a light reddish brown, slightly alkaline clay, and was fertile compared with soils of other stands (Table VI). It closely resembled the soil of the more mature Red River floodplain stand. Sand was occasionally encountered from a few inches down to a foot or more. At other locations, clay can be found down to the three foot level. Ditches cut by farmers for drainage or other purposes showed that almost pure sand was encountered at varying distances below a layer of reddish clay. Where the river moved south in its meanderings, dune areas usually

Table IV. Importance percentages of seedlings and saplings of forest stands studied. An x represents a value of less than 5 per cent.

Species	BB	OR	YR	A	WE	WW	PE	PW	WF	GL	BL	DC	KC
Fraxinus pennsylvanica	56		22	15							12		15
Celtis spp.	37	26	x	10	x			x	x	14	22	35	18
Ulmus crassifolia	x									x		45	37
Gleditsia triacanthos	x	x			x				x		16	x	
Sapindus drummondii		26											6
Morus rubra		15	10	8		x				x	x		
Ulmus rubra		13											
Maclura pomifera		6	x							x	15	14	10
Acer negundo		x	x										
Carya illinoensis		x	x								x		x
Sophora affinis		x											
Quercus muehlenbergii		x								x			x
Ulmus americana		x	x							x			
Salix nigra			20										
Populus deltoides			16										
Juniperus virginiana			11								5		
Diospyros virginiana			x		x					x	x		
Cornus floridana			x		6			x					
Quercus velutina			x	5	7	17	16	12		x			
Ulmus alata				48	58	52	48	37	39	35	17		
Q. stellata				18	x	22	17	12	25	5			
Carya texana				7	10	x	8	17	x	5			
Q. marilandica				x		x	x	x					
Q. rubra				x									
Q. falcata				x	8		x			x			
Sassafras albidum				x									
Prunus spp.				x									
Carya tomentosa					x		x						
Cercis canadensis								9	x	6			
Fraxinus americana								x	19	19			
Bumelia lanuginosa								x	x		x		x
Quercus shumardii										x		x	
Crataegus spp.											x		
Q. nigra											x		

Stand abbreviations given at the bottom of Table I.

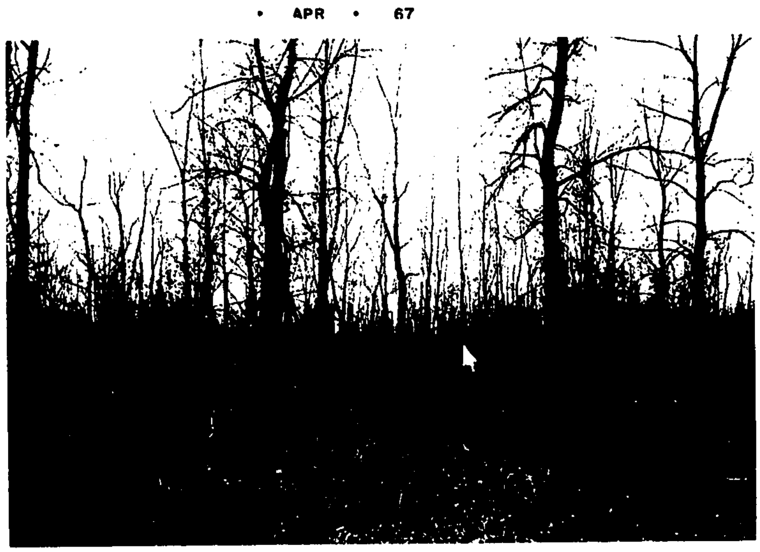

Figure 5. Young Red River Stand

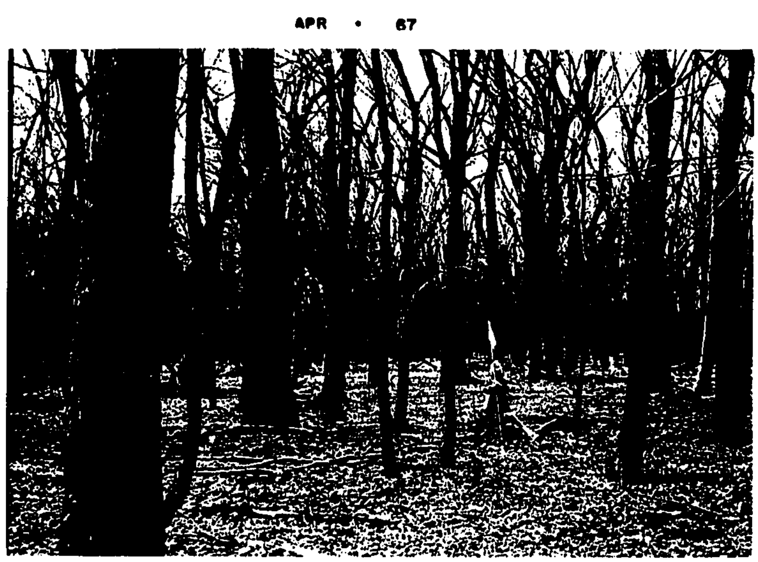

Figure 6. Old Red River Stand

formed north of the sandy bed recently vacated. Before the impoundment of Lake Texoma, these dune areas were periodically inundated by the muddy water of the Red River. Sediment coming mainly from the Permian Red beds farther west is deposited over the dunes, forming the present surface. The soil of the floodplain is one of the most fertile and most productive in southeastern Oklahoma. The effect of stage of succession or maturity of a forest community on the soil in which it grows was well demonstrated by the difference of total phosphorus, total nitrogen, and organic matter (Table VI) between this stand and the Old Red River Stand.

Old Red River Stand

This was a relatively typical elm-ash-hackberry bottomland forest and corresponded to forest cover type 85. Ulmus rubra was the main species of elm. The basal area of 143 sq. ft. per acre was highest of all the stands investigated. It had the next d.b.h. which averaged 10.5 inches, but was relatively open (Table III). The Society of Foresters (1931) considered this type temporary and one which developed after heavy cutting. However, the study stand showed no sign of ever having been lumbered. In the central and west central part of Oklahoma, elm-ash-hackberry is the usual type of most mature bottomland stands (Bruner 1931). Associated species such as Quercus macrocarpa, Q. Shumardii, and Q. muehlenbergii seldom become dominent and usually compose a minor portion of such stands. Farther west, near the western border and in the Panhandle, willow and cottonwood persist without being

Table V. Importance percentages of common shrubs and vines in forest stands studied. An x represents a value of less than 5 per cent.

Species	BB	OR	YR	A	WE	WW	PE	PW	WF	GL	BL	DC	KC
Campsis radicans	19	9											
Ilex decidua	18		x	x	x	x	x	x		x	4		
Parthenocissus quinquefolia	13	49		36	20	33	21	31	x	14	x		
Vitis spp.	13	8		x	11	15	20	21	x	x			
Crataegus spp.	8			x	x		x	x	21	9	7		11
Rhus toxicodendron	x	7	x	20	32	13	37	x		33	9		
Smilax spp.	x	x		20	x	7		12	53	18	18		
Berchemia scandens	x	x		7	x	x	x			x	18		
Symphoricarpos orbiculatus		8		x	6		x	8	8	x	39		74
Cornus drummondii			42			x				x			
Rubus spp.			34			x							
Cocculus carolinus*			x		x	x					x	x	x
Rosa foliolosa				x	x		5						
Rhus copallina					11	x	x	x					
R. glabra					x		x	5	x	x			

* - Cocculus carolinus was included in the list, although its value was less than 5 per cent in all stands, because it was the only species of shrub-vine encountered in the Duck Creek Community.

Stand name abbreviations explained at the bottom of Table II.

succeeded by an elm-ash-hackberry type. Perhaps as one moves away from optimum climatic conditions, the stages to which succession can proceed becomes successively lower. Only willow and cottonwood persist in the Panhandle, elm-ash-hackberry occurs in the central and western half of the state, but oaks, gums, maples, and cypress are common in the east. The seedlings of Ulmus rubra and Celtis spp. made up a large portion of the reproduction of the stand, with Fraxinus pennsylvanica comprising only a minor portion (Table IV). The most common shrub was Symphoricarpos orbiculatus with Campsis radicans, Parthenocissus quinquefolia, and Vitis spp. as the more common vines (Table V).

The physical properties of the soil of this stand were very close to that of the Young Red River Stand. It had approximately a fourth more total phosphorus and about a third more total nitrogen and carbon per acre (Table VI).

Antlers Sand Stand

This stand represented a good upland forest, principally of Quercus stellata and Carya texana (Table II). The basal area per acre of 89 sq. ft. for this stand was next to the highest for the sandy soils. It was a relatively closed stand with an average d.b.h. of 7.3 inches. (Table III). Ulmus alata had the highest number of seedlings and saplings. There were also seedlings of Quercus stellata, Celtis sp., Q. velutina, and Fraxinus pennsylvanica (Table IV). Only an occasional shrub was encountered, but Smilax spp., Rhus toxicodendron, and Parthenocissus quinquefolia were common vines in the understory (Table V).

The surface soil is a light yellowish brown, essentially

Table VI. Physical and Chemical soil Factors of the study stands. Pounds per acre are based on an acre furrow slice.

Stands	% Sand	% Silt	% Clay	pH	Total Phosphorus lbs./acre	Total Nitrogen lbs./acre	Organic Carbon lbs./acre	$\frac{C}{N}$	Compaction g/cc
Bottomland Stands									
Clear Boggy Creek	20.1	12.9	67.0	8.0	2,273	3,666	34,053	9.29	1.05
Red River Alluvium									
Young Stand	28.6	19.4	52.0	7.6	1,664	1,594	12,688	7.96	0.92
Old Stand	27.2	21.9	50.9	7.4	2,088	2,488	19,458	7.82	0.96
Upland Stands									
Sandstone Formations									
Antlers Sand	86.6	7.0	6.4	7.3	301	442	4,925	11.14	1.13
Woodbine East	77.8	15.2	7.0	7.2	203	260	4,022	15.48	1.08
Woodbine West	88.2	7.3	4.5	6.9	287	350	5,060	14.46	0.98
Pawpaw East	85.6	8.4	6.0	6.2	309	556	5,340	9.60	1.03
Pawpaw West	88.9	5.4	5.7	6.6	541	314	6,470	20.61	1.03
Weno formation	23.6	55.6	20.8	6.2	1,154	3,615	9,822	7.10	1.38
Limestone formations									
Goodland L.	62.6	13.4	24.0	7.8	1,956	5,450	52,716	9.67	1.17
Bennington L.	43.6	45.9	10.5	7.3	1,861	2,768	33,139	11.97	1.27
Duck Creek L.	35.6	21.1	43.3	7.6	1,868	4,332	40,471	9.34	1.01
Kiamichi Clay	35.6	14.4	50.0	7.2	2,149	6,074	55,115	9.08	1.27

neutral sand. It is low in fertility and apparently very susceptible to leaching (Table VI).

Woodbine Sand Stands

The principal species of these two stands were Quercus stellata, Q. velutina, and Carya texana. Quercus falcata and Carya tomentosa occur in the eastern stand with the former having a slightly higher importance percentage than Q. velutina; neither were found in the western stand (Table II). The basal area of 90 sq. ft. per acre was highest of any sandstone stand (Table III). Ulmus alata had the highest number of seedlings and saplings in both stands as it did in the other sandstones, Goodland limestone, and Weno formation stands. However, it formed a minor portion of the tree canopy (Table III and IV). Shrubs were not common in the understory, but three vines, Rhus toxicodendron, Parthenocissus quinquefolia, and Vitis spp. were relatively common (Table V).

The surface soil of these two stands, with some slight exceptions, were very much alike, although they are located 40 miles apart. Their color, texture, pH, and phosphorus content were essentially the same (Table VI). The slightly lower nitrogen, carbon, and organic matter content, as well as the slightly higher volume weight of the soil of the eastern stand, might have been the result of slightly increased leaching. The eastern stand was somewhat more open, and occurred in an area with about four inches more annual precipitation. These facts might have contributed to increased leaching in the eastern stand.

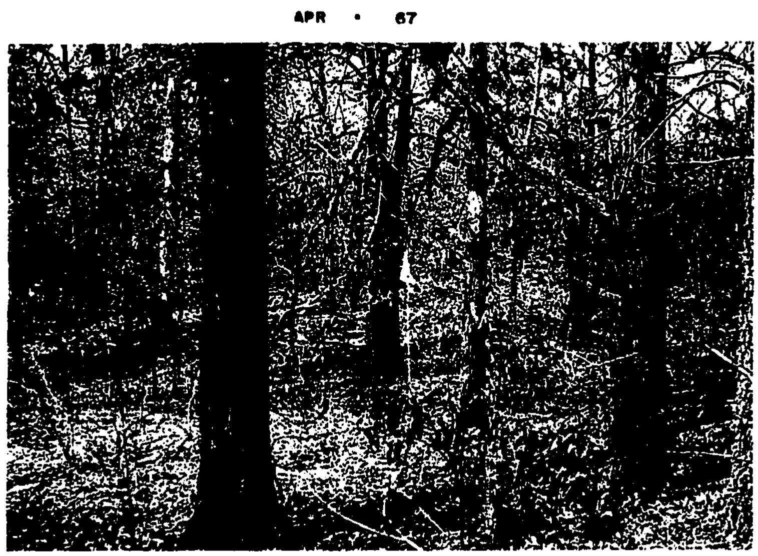

Figure 7. Woodbine Sand East Stand

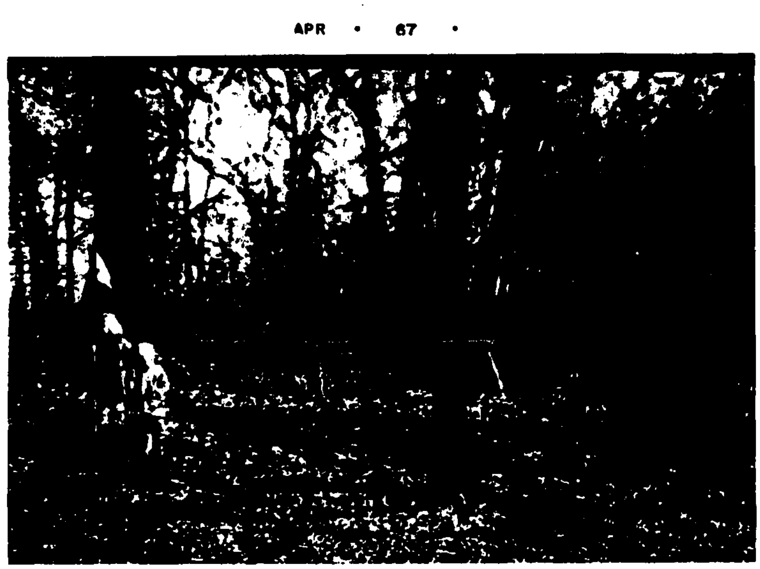

Figure 8. Woodbine Sand West Stand

Pawpaw Sand Stands

The vegetation of these two stands was essentially the same with Carya texana, Quercus stellata, and Q. velutina having higher importance percentages in the eastern stand. Quercus marilandica replaced Q. velutina in importance in the western stand. Quercus falcata and Carya tomentosa were absent from the latter (Table II). The eastern stand had the lowest basal area of any stand, 66 sq. ft. per acre (Table III). Ulmus alata, Quercus stellata, and Carya texana were the common seedlings and saplings in both stands (Table IV). Vines were the more common members of the understory, principally Parthenocissus quinquefolia, Rhus toxicodendron, Smilax spp. and Vitis spp. Species of Vitis had their highest importance in the eastern stand, whereas Smilax was found only in the western stand (Table V).

The soils of these two stands, like those of the Woodbine stands, were much alike (Table VI). It seems probable that the slight differences in the nutrient content values of the four sandy soils are differences due to chance sampling.

The vegetation and soils of the four stands on the Woodbine and Pawpaw were alike in many respects. Of the three black oaks, Quercus marilandica, Q. velutina, and Q. falcata, that occurred in these stands, Q. marilandica was able to grow in dryer habitats, with Q. velutina and Q. falcata in progressively more mesic habitats. Preston (1961) described the habitats of these three species as Q. marilandica, dry sites; Q. velutina, dry to moist sites; and Q. falcata as dry to wet sites; If the relative abundance of these three

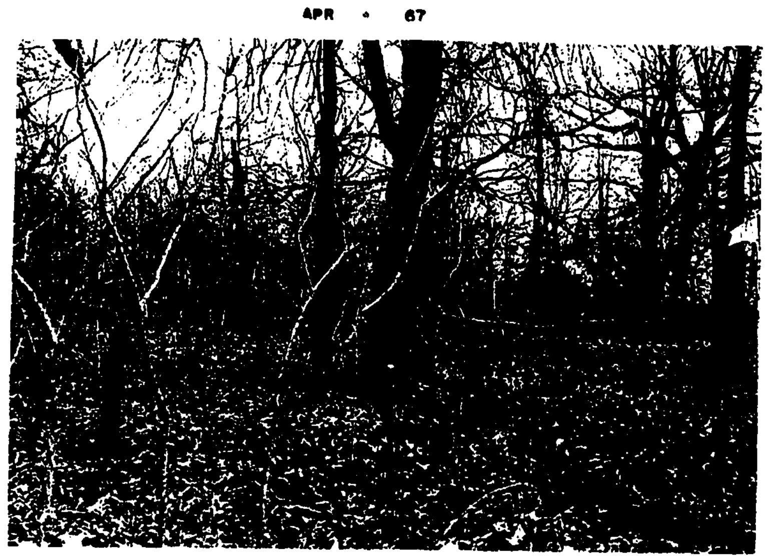

Figure 9. Pawpaw Sand East Stand

Figure 10. Pawpaw Sand West Stand

species and Carya tomentosa in a stand is indicative of the degree of xeric conditions in that stand, the Pawpaw stands were slightly more xeric in nature than the Woodbine stands and the western stands of both a little more xeric than their eastern counterpart. (Table II). This might have been simply a response to the lower average annual precipitation in the western part of the area of four inches.

Weno Formation Stand

The vegetation of this stand was composed mainly of Quercus stellata, Fraxinus americana, and Ulmus alata (Table II). This stand had a basal area of 62 sq. ft. per acre which was third lowest of the stands investigated. Its mean d.b.h. was 6.1 inches (Table III). This combination was similar to a stand discussed by Hutcheson (1965). The community seemed to be maintaining itself as most seedlings and saplings belonged to the three major species. Species of Crataegus were the most common shrubs, and species of Smilax were the common vines.

According to soil surveys and geological descriptions (Olson 1965), the soil from this geological material should have been more like that of the sandy formation than my analysis indicated. Except for its coarse texture and pH values, this soil was certainly more closely allied to soils of the limestone and clay stands, although its nutrient values were generally lower (Table VI). The soil volume-weight was highest of any stand.

Figure 11. Weno Formation Stand

Goodland Limestone Stand

Several different types of plant communities grew on soils from this formation. In the study stand, Carya texana and Quercus stellata had the highest importance percentage, but 17 different tree species were counted in the sample. Q. falcata was the main secondary species (Table II). This stand had the highest number of trees, 277.5 per acre, but since its d.b.h. of 6.8 inches was relatively low, the basal area per acre was only 85 sq ft. Other stands of similar composition were located in Marshall, Choctaw, and McCurtain Counties. Ulmus alata, Fraxinus americana, and Celtis spp. were reproducing extensively (Table IV). There were a number of species of shrubs, but Crataegus spp. were the most common. Common vines were Smilax, Rhus toxicodendron, and Parthenocissus quinquefolia (Table V).

Although the soil had a very high sand content; soil color, pH, and general fertility was much like that of soils from the other limestones and clays (Table VI).

Bennington Limestone Stand

The vegetation of this stand was composed mainly of Celtis spp., Maclura pomifera, and species of Ulmus. Gleditsia triacanthos was also an associate member. In basal area per acre and soil texture this stand, like that of the Goodland limestone, was similar to those of the sandstones. But its major species were those common to the Duck Creek, Kiamichi, and bottomlands. Celtis and Maclura had the highest number of seedlings and saplings (Table IV). Symphoricarpos orbiculatus was the most common shrub, Berchemia scandens and Smilax spp. were the

APR • 67

Figure 12. Goodland Limestone Stand

APR • 67

Figure 13. Bennington Limestone Stand

more common vines (Table V).

This soil, like that of the Goodland, had a relatively high sand-silt content. The soil of the Weno formation was the only soil containing a larger percentage of silt. The soil from the Bennington limestone had a slightly lower nitrogen, organic carbon, and organic matter content; but it was still similar to the other limestone and clay soils (Table VI). The soils of the Weno Formation, Goodland and Bennington limestones were all relatively coarse textured, had poorly developed profiles, and were shallow, with rock at the surface in places. Dix (1959) pointed out shallow soils often have only A and D horizons. Black (1957) stated that while sand and silt fractions might represent residual unweathered or physically weathered material, the clay was more dependent on the processes of chemical weathering.

Duck Creek Limestone Stand

This stand was composed of *Ulmus crassifolia* and *Maclura pomifera*. *Ulmus crassifolia* was often encountered growing in tight shallow, stoney, clay soil in upland stands, but it was more commonly found in bottomlands. The basal area of 25 sq. ft. per acre was by far the lowest of any stand, largely because of an average d.b.h. of only 5.1 inches. Both major species were maintaining their importance as indicated by seedlings and saplings (Table IV). The only understory species in this stand was *Cocculus carolinus* (Table V).

Much of the soil on this formation was under cultivation, or had been cleared of woody species for meadows or pastures. The study

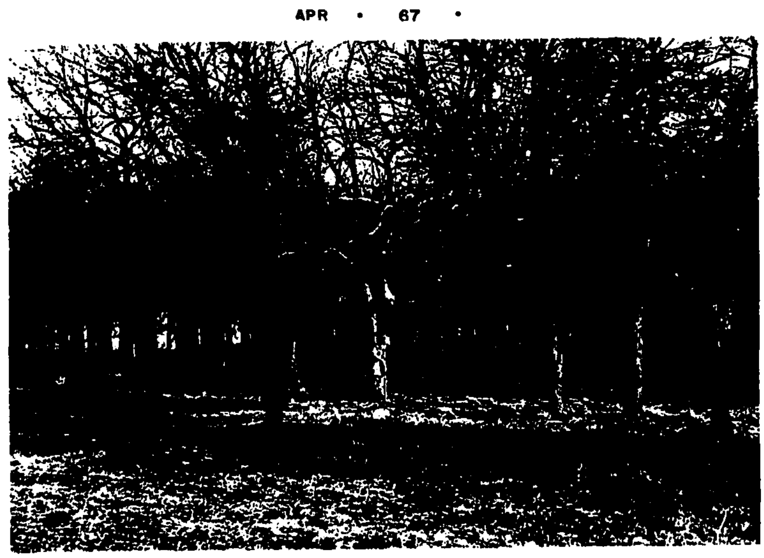

Figure 14. Duck Creek Limestone Stand

Figure 15. Kiamichi Clay Stand

stand had evidently developed since cultivation was abandoned about 30 years ago. This dark gray to gray-brown, moderately alkaline, clay loam was relatively high in soil nutrients. It had the lowest volume-weight of the limestone and clay soils (Table VI).

Kiamichi Clay Stand

Ulmus crassifolia and Maclura pomifera were the only species obtained in the sample of this stand, although a few trees of Fraxinus pennsylvanica occur. Basal area per acre was 62 sq. ft. and the mean d.b.h. of the stand was 5.7 inches. The three above species constituted the major portion of seedlings and saplings (Table IV). Both this stand and that of the Duck Creek are variations of the same forest type. Symphoricarpos orbiculatus was the main understory species.

Similarities in the physical properties of the soil of the Kiamichi Clay and Duck Creek Limestone are to be expected since the former is derived in a large measure from clay and the lime cement of the oyster shell limestone, and the soil of the Duck Creek is formed mainly from soft chalky limestone and clay. These stands are about one-half mile apart, thus have similar climatic conditions. The soil of the Kiamichi was a gray-brown, neutral, rather tight waxy clay that had about the highest fertility of any stand (Table VI). The stands of the last two formations also had shallow soils with poorly developed profiles.

DISCUSSION

If Celtis spp., Crataegus spp. and Prunus spp. are considered only as three species, as they were for the purpose of this study, a total of 32 species of trees were encountered in the samples of the 13 stands. On this same basis there were 49 species of trees listed in my field notes for the Bryan County area. Of the 32 tree species, only 13 had an importance percentage of 15 or more for at least one stand. There were four others with an importance percentage of less than 15 but more than five.

In general the species in this study can be placed in three categories: those that occur predominantly in the bottomlands; species that occur mainly on soils derived from sandstone; and those that occur on soils derived from limestones and clays. It is evident that some overlap occurs as the species on Goodland limestone seem more closely related to the species on the sandstones, whereas those on the Bennington limestone and clays seem more closely allied to those of the bottomlands. There were 14 species that had their highest importance percentages or occurred only in stands on predominantly coarse-textured soils. Soils predominantly of sand and silt are considered as coarse-textured soils (Lyon and Buckman 1943, Black 1957, and U. S. Dept. Agric. 1957). Of the 14 species, there were nine with an importance percentage of at least five per cent in one or more stands. There were 13 species that had their highest importance percentage or occurred only in stands that grew in soils which were mainly fine-textured. Lyon and Buckman (1943) stated that a soil with at least 30 per cent clay was considered a clay soil. This would include soil of the three bottomlands, the Duck Creek limestone, and Kiamichi clay. The stands with the largest average tree size and highest basal area per acre were in the bottomlands, whereas the highest number of trees per acre occurred on the Goodland limestone and the Kiamichi clay. The most open stand was the Clear Boggy Creek stand. The average basal area per acre for all stands was 78.6 square feet per acre. The average for the three bottomland stands was 99.5, that of the stands on sandstone derived soils was 77.2, and the average of stands on limestone and clay soils was 65.1. The basal areas per acre of the Goodland and Bennington limestone stands were more like those of sandy soil stands rather than the clay soil stands. If total nitrogen, total phosphorus, and organic carbon are used as an index of fertility, stands growing on soils derived from limestone and clay were the least productive, but grew on the most fertile soil.

The average basal area per acre for the 13 stands of this study was essentially the same (78.74 sq. ft.) as that found by Taylor (1965) for an 80 acre stand growing on the Antlers Sand. His study was conducted approximately eight miles west of the Antlers sand stand of this study. Rice and Penfound (1959) found an average basal area per acre of only 55.2 sq. ft. for their three Bryan County stands. Two of their stands were on soils derived from the Woodbine sand, while the third was underlain by the Pawpaw sand. They reported average basal areas per acre as follows: *Quercus stellata* 23.0; *Q. marilandica* 7.7; *Q. velutina* 10.2; *Carya texana* 9.4. The average basal area per acre of those species in the four stands of this study on the same formations were 25.6, 7.2, 12.8, and 19.3 square feet respectively. The eastern stands of the Woodbine and Pawpaw formations seemed to be slightly more mesic than the western ones on the same formations. The Woodbine stands appeared to be a little more mesic than the Pawpaw stands.

Using the same criteria for seedlings and saplings as that used for tree species, there was a total of 34 species encountered in all stands. Four of the 34 were not encountered as trees and two species tabulated as trees were not found as seedlings and saplings. Only 14 species had an importance percentage of 14 or more in at least one stand. Of this number *Morus rubra* and *Salix nigra* had lower percentages as trees. *Sapindus drummondii* was not tallied as a tree for any stand. Seedlings and saplings of *Platanus occidentalis* and *Quercus macrocarpa* were not tallied although they occurred as trees.

There were 14 species of shrubs and 10 vines tallied for all stands, whereas my field notes include 34 shrubs and 18 vines for the Bryan County area. In general, vines were much more common than shrubs in the study stands. Only two species of shrubs were found in the Kiamichi clay and none were encountered in the Duck Creek limestone stand. Both had only one species of vine, *Cocculus carolinus*.

Two types of forest communities of interest encountered in this study were the post oak-white ash-winged elm and the hackberry-cedar elm-green ash. The first has only recently been described from the Arbuckle mountain area by Hutcheson (1965). The latter does not seem to have been reported for Oklahoma.

When soil factors of the stands were analyzed, it was found that soils derived from 1) sandstone, 2) limestone and clay, and 3) bottomlands differed considerably. Soils of the latter two were much alike in a number of factors and were sharply distinct from the sandstones, except for pH and soil volume-weight. The Goodland limestone and Bennington limestone had soil textures that were more like those of the sandstones than the other soils. These two, with the soil from the Weno formation, might have been placed in a separate category. The soil reaction (pH) ranged from slightly acid to moderately alkaline (6.2-8.0). The pH of most stands were within or close to the neutral range, 6.6-7.3, for soils (Gray and Galloway 1959), and probably was not sufficiently high or low to be critical in any of the stands. Gray and Galloway (1959) stated that a pH range of 6.1 to 7.3 was optimum for the growth of most organisms. Although the sandstone soils were much lower in fertility, all but the Pawpaw east and Weno formation soils had their colloidal complexes essentially base-saturated (Erye 1963). Black (1957) stated that soil nitrogen increased as the soil texture became finer. If the clay content was used as an index of soil texture, the Goodland limestone with only 24 per cent clay provided an exception. It had next to the highest amount of nitrogen, whereas the Clear Boggy Creek soil with 67 per cent clay had much less nitrogen per acre. When the colloidal portion of organic matter, which may have an exchange capacity twice that of some clays (Thompson 1952), and the clay portion were considered together; the texture and nitrogen relationship correlated well. The same correlation existed with soil phosphorus. There also seemed to be some correlation between these factors and soil volume-weight.

There were nine species of trees that occurred mainly on coarse-textured soils, with their highest importance percentages on sandy soils which were lowest in total nitrogen and phosphorus. They were Quercus stellata, Q. velutina, Q. marilandica, Q. falcata, Ulmus alata, Carya texana, C. tomentosa, Cercis canadensis, and U. americana. Celtis spp., Fraxinus pennsylvanica, Maclura pomifera, and Ulmus crassifolia had their highest importance percentages on fine-textured soils, both in bottomlands and uplands. All but U. crassifolia had seedlings on most of the coarse-textured soils. A number of the remaining species seemed restricted to bottomlands with an occasional occurrence in upland stands. Anderson (1954) suggested that a number of species of trees, as elms, sycamore, and honey locust, which were usually found in bottomlands, occasionally occurred in uplands where some kind of disturbance laid bare the topsoil. Bottomlands that flood seasonally were continually disturbed by inundation and deposition of silt. The shallow soils of the Bennington limestone, Duck Creek limestone, and Kiamichi clay were probably very susceptible to disturbance. A number of pioneer weedy species are known to have a wide ecological amplitude (Harlan and deWet 1965). Foote and Jackobs (1966) found Cassia fasciculata, for example, on soils with a wide range of ecological conditions. This may also be the case of such tree species as Celtis sp., Diospyros virginiana, Fraxinus pennsylvanica, Gleditsia triacanthos, Maclura pomifera, Ulmus alata, and U. crassifolia. The Society of American Foresters (1931) listed some of these species in both bottomland and upland communities, some of which occurred on dry limestone hills. If disturbance is a factor, it would help to explain why some of the tree species could be important components in both bottomland and dry uplands. *Ulmus crassifolia* was found as a tree mainly on soils containing more than 30 per cent clay whereas *U. alata* occurred as a tree on soils having less clay. Although both species occurred in many kinds of habitats, both bottomland and upland, *U. crassifolia* apparently preferred fine-textured soils, *U. alata* coarse-textured soils.

In general the distribution of seedlings and saplings corresponded to the soils on which trees of that species also occurred. The number of seedlings and saplings was low in the two Red River stands, the Duck Creek limestone, and Kiamichi clay. Shrub and vine species in this study did not seem to be restricted to any soil type. This agreed with the findings of Hutcheson (1965).

The one soil factor which seemed to be most influential in the distribution of species of trees as found in this study was soil texture. Soil texture, however, either directly or indirectly, affected most other soil factors, including rate of water infiltration, available water, soil aeration, and soil nutrient content (Black 1957). Soil texture, as well as a number of other soil properties, were known to be related to the geological material from which it was formed (Gray and Galloway 1959). Usually coarse-textured soils developed from sandstone, and other sandy material, whereas fine-textured soils developed from such materials as clays, marls, and soft limestone. However, soils of the same texture may develop from a number of different substrates. Wright and Mooney (1965) found that quite similar soil, including texture, developed from dolomite and from sandstone. Quarterman and Keever (1962) found sandy surface soils developed above a number of different kinds of materials including limestone. They found no correlation between soil fertility and types of forest stands. In this study, coarse-textured soils were found on the sandstone formations, Weno formation, Bennington limestone, and Goodland limestone; whereas fine-textured soils were found on the alluvium, Duck Creek limestone, and Kiamichi clay.

SUMMARY

In this study the vegetation of 13 forest communities was analyzed. The soil in which they grew was also studied and the communities correlated with soil and geological material. All stands were located in the Bryan County portion of the Oklahoma Gulf Coastal Plain. These forest stands were established on the following geological formations: Clear Boggy Creek alluvium, Red River alluvium, Antlers sand, Pawpaw sand, Woodbine sand, Weno formation, Goodland limestone, Bennington limestone, Duck Creek limestone, and Kiamichi clay.

Extensive reconaissance resulted in the selection of 13 forest stands on the above formations. Sampling was accomplished by point-centered quarter method, with the number of plants, basal area of trees. and importance percentage as the most useful parameters. Soil factors studied included soil texture, soil reaction, amounts of organic carbon, total nitrogen, and total phosphorus, and the degree of soil compaction.

Of the 13 stands, three grew in bottomlands, six grew on sandy substrates, and four occurred on limestone or clay-derived soils. In addition these stands allowed comparison of forest communities growing on the same formations 40 miles apart, and two different stages of succession.

In the bottomland communities, the species with the highest importance percentages were *Celtis* sp., *Fraxinus pennsylvanica*, *Populus* deltoides, Ulmus crassifolia, and U. rubra. The most important species growing in stands on coarse-textured soils, including the Goodland limestone stand, were Carya texana, Quercus falcata, Q. marilandica, Q. stellata, Q. velutina, and Ulmus alata. The dominant species on the Kiamichi clay, Bennington and Duck Creek limestone were Celtis sp., Maclura pomifera, and Ulmus crassifolia. On the basis of basal area, the bottomlands were the most productive, sandy soils intermediate, and upland fine-textured soils least productive although the most fertile.

In comparing two bottomland stands representing early and late stages of succession, it was found that physical properties of their soils were very similar, but that the soil of the mature stand was more fertile and more productive. The soil properties of the Pawpaw and Woodbine formations were similar both in physical and chemical properties, although eastern and western stands were 40 miles apart. The eastern stands were slightly more mesic.

As a general rule, seedlings and saplings of the overstory species were abundant in all stands except the cottonwood stand on Red River alluvium. Shrubs and vines were common, but not abundant in all stands. Vines were more numerous in most communities than shrubs.

Based on the results of this study, the most important soil factor influencing the distribution of trees and forest communities was soil texture. No correlation between soil type and either shrubs or vines was observed.

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