SOIL SURVEY

McLennan County Texas

Series 1942, No. 17

Issued May, 1958

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with the
TEXAS AGRICULTURAL EXPERIMENT STATION

How to Use THE SOIL SURVEY REPORT

FARMERS who have worked with their soils for a long time know about differences among soils on their farms, and perhaps about differences among soils on the farms of their immediate neighbors. What they do not know, unless soil surveys have been made, is how nearly their soils are like those on experiment stations or on other farms, either in their State or other States, where farmers have gained experience with new or different farming practices or farm enterprises. They do not know whether higher yields obtained by farmers in other parts of their county and State are from soils like theirs or from soils so different that they could not hope to get yields as high, even if they followed the same practices. One way for farmers to avoid some of the risk and uncertainty involved in trying new production methods and new varieties of plants is to learn what kinds of soils they have so that they can compare them with the soils on which new developments have proved successful.

SOILS OF A PARTICULAR FARM

The soil map accompanies the soil survey report. To find what soils are on any farm or other tract of land, it is necessary first to locate the tract on the map. This is easily done by using roads, streams, villages, dwellings, and other landmarks to locate the boundaries.

Each kind of soil mapped within the farm or tract is marked on the map with a symbol. For example, all the areas marked BE are Bell clay, 0 to 1 percent slopes. The color in which the soil area is shown on the map will be the same as the color indicated in the map legend for the particular type of soil. If you want information on the Bell soil, turn to the section in this publication, Descriptions of the Soils, and find Bell clay, 0 to 1 percent slopes. Under this heading you will find something about the characteristics of this soil, and what the soil is mainly used for.

Suppose, for instance, you wish to know the probable yields on Bell clay, 0 to 1 percent slopes. You will find the soil listed in the left-hand column of table 7. Opposite the name you can read the yields for the different crops grown on it. This table also gives estimated yields for all the other soils mapped in the county.

If, in addition, you wish to know what uses and management practices are recommended for Bell clay, 0 to 1 percent slopes, refer to the section headed Use and Management of Soils. In this section the soils suited to the same uses and management practices are grouped together.

SOILS OF THE COUNTY AS A WHOLE

A general idea of the soils of the county is given in the section, Soils of McLennan County, Texas, which tells about the principal kinds of soils, where they are found, and how they are related. After reading this section, study the soil map and notice how the different kinds of soils tend to occur in different parts of the county. These patterns of occurrence are likely to be associated with well-recognized differences in type of farming, land use, and land-use problems.

A newcomer to the county, especially if he considers purchasing a farm, will want to know about the climate, the principal farm products and how they are marketed; the sizes of farms; farm tenure; transportation facilities, electric services, and water supplies; industries; and cities, villages, and population characteristics. Information about all these will be found in the section, General Description of the County, and in the section, Agriculture.

Those interested in how the soils of the county were formed and how they are related to the soils of the world should read the section, Morphology and Genesis of Soils. Engineers planning highways will be interested in the section, Engineering Applications.

Series 1942, No. 17 Issued May, 1958

SOIL SURVEY OF McLENNAN COUNTY, TEXAS

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United States Department of Agriculture in cooperation with the Texas Agricultural Experiment Station

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[1] Field work was done while Soil Survey was part of the Bureau of Plant Industry, Soils, and Agricultural Engineering. Soil Survey was transferred to the Soil Conservation Service November 15, 1952.

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THE soil survey of McLennan County was made by the United States Department of Agriculture and the Texas Agricultural Experiment Station. Field work was begun in 1940 and completed in 1942. The latest available census and weather information has been incorporated in tables in the report; otherwise statements in this report refer to conditions in 1942.

GENERAL DESCRIPTION OF THE COUNTY

LOCATION AND EXTENT

McLennan County is in the prairie region of central Texas (fig. 1). Waco, the county seat and principal city, is 85 miles south of Dallas and 160 miles northwest of Houston. The county is approximately 38 miles long and 28 miles wide. The longer axis is at right angles to the general course of the Brazos River. The total area is approximately 1,040 square miles, or 665,600 acres.

PHYSIOGRAPHY AND RELIEF

The eastern three-fourths of the county is in the Blackland Prairie of Texas; the western one-fourth is in the Grand Prairie (fig. 2). The estimated acreages of geographic subdivisions in McLennan County are shown by slope classes in table 1.

The Blackland Prairie, one of the major geographic divisions of Texas, is a gently rolling prairie underlain by marls, calcareous clays, and chalk. It is a 9-million-acre area of dark, deep, mostly clayey and limy, grassland soils comprising a belt about 20 to 75 miles wide and 300 miles long. This belt, which is the interior part of the Gulf Coastal Plain, is parallel to the coast and about 250 miles inland. In the vicinity of McLennan County, which lies in the western half of the Blackland Prairie, the belt is about 50 miles wide. The part of McLennan County lying within the Blackland Prairie section com-

TABLE 1.—*Estimated land areas of the geographic subdivisions of McLennan County, Tex., by slope classes*

Location and slope classes	Blackland Prairie section			Grand Prairie	Total
	Blackland Prairie proper	Brazos River bottoms [1]	Sandy forested upland		
All land other than flood plain:					
Level (gradients less than 1 percent)	*Acres* 51, 500	*Acres* 11, 700	*Acres* 6, 600	*Acres* 13, 800	*Acres* 83, 600
Gently sloping (gradients 1 to 4 percent)	219, 000	2, 300	25, 500	121, 100	367, 900
Moderately sloping (gradients 4 to 8 percent)	62, 000	1, 400	4, 400	22, 100	89, 900
Strongly sloping (gradients 8 to 20 percent)	15, 800	[2]	200	3, 000	19, 000
Steep (gradients more than 20 percent)	8, 900	[2]	-------	5, 800	14, 700
Total	357, 200	15, 400	36, 700	165, 800	575, 100
Flood plain	42, 500	29, 200	-------	12, 600	84, 300
Total acreage [3]	399, 700	44, 600	36, 700	178, 400	[3]659, 400

[1] Comprise the flood plain of the Brazos River and border low terraces occupied by Bastrop, Brewer, and Vanoss soils.

[2] Trace.

[3] Does not include 6,600 acres of water area (Blackland Prairie, 3,800 acres; Brazos River bottoms, 2,700; and Grand Prairie, 100).

prises approximately 500,000 acres. This, however, includes the Brazos River bottoms and some areas of forested sandy upland that, though of different geology, are essentially southern extensions of the Eastern Cross Timbers area.

The Grand Prairie, another major geographic division that continues far beyond the limits of western McLennan County, is a plain underlain by limestone. It is hard-rock prairie and differs from the Blackland Prairie in being somewhat more rolling and in including major proportions of stony and shallow soils. In McLennan County the boundary between the two geographic subdivisions is obscure but it follows the eastern limit of the limestone outcrops and the soils are underlain by limestone within a depth of 4 feet. The greater part of the Grand Prairie section of this county is gently rolling, somewhat less rolling than characteristic. In the northwestern part of the county, however, there are a considerable number of moderate to steep slopes, and some of the larger streams, especially the Middle Bosque River and Bluff Creek, have canyons as deep as 100 feet.

Although gently rolling terrain prevails within the county, there are several rolling to hilly sections and some broad undissected flats.

The main rolling and hilly areas are: (1) Escarpments, (2) strongly rolling belts along streams, and (3) canyons.

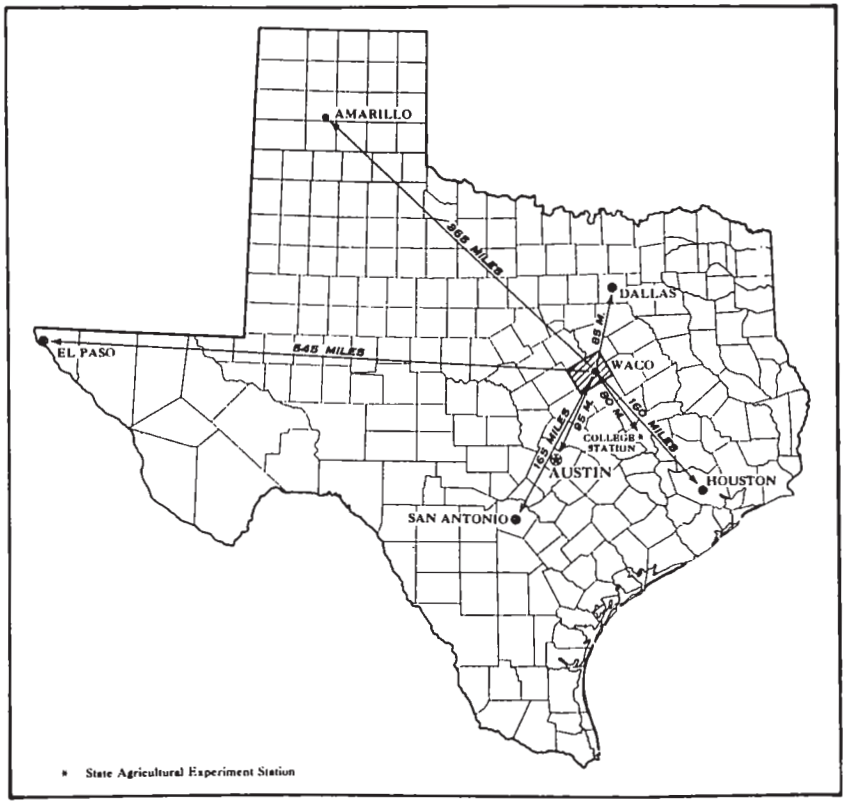

FIGURE 1.—Location of McLennan County in Texas.

Chief among the first of these areas is the Bosque escarpment, a north-south belt of west-facing hills that crosses the middle of the county. This belt of hills extends into southwestern McLennan County just west of the Santa Fe railroad. It occurs along the west side of the railroad to a point about 4 miles northwest of Moody on the divide between the Leon and Bosque Rivers. From this point it follows a northeasterly direction along the south side of the South Bosque River and terminates in the chalk bluffs of northern Waco. Near Moody this escarpment is formed by flagstones in the Eagle Ford formation; between Moody and Waco it merges with the White Rock escarpment formed by the Austin chalk. From the junction of these two, which is midway between Spring Valley and South Bosque, a more easterly line of hills extends southeast, south, and west to a point on the county line about 3 miles southwest of Eddy. North of the Brazos River, these escarpments form the broken area along the lower course of White Rock Creek, the chalk bluffs that border the Brazos River on the east between Aquilla and White Rock Creeks, the hilly slopes along the west side of Aquilla Creek, and the chalk escarpment near the town of West.

The strongly rolling belts along streams comprise the moderate to strong slopes that border the prairie streams in the eastern part of the

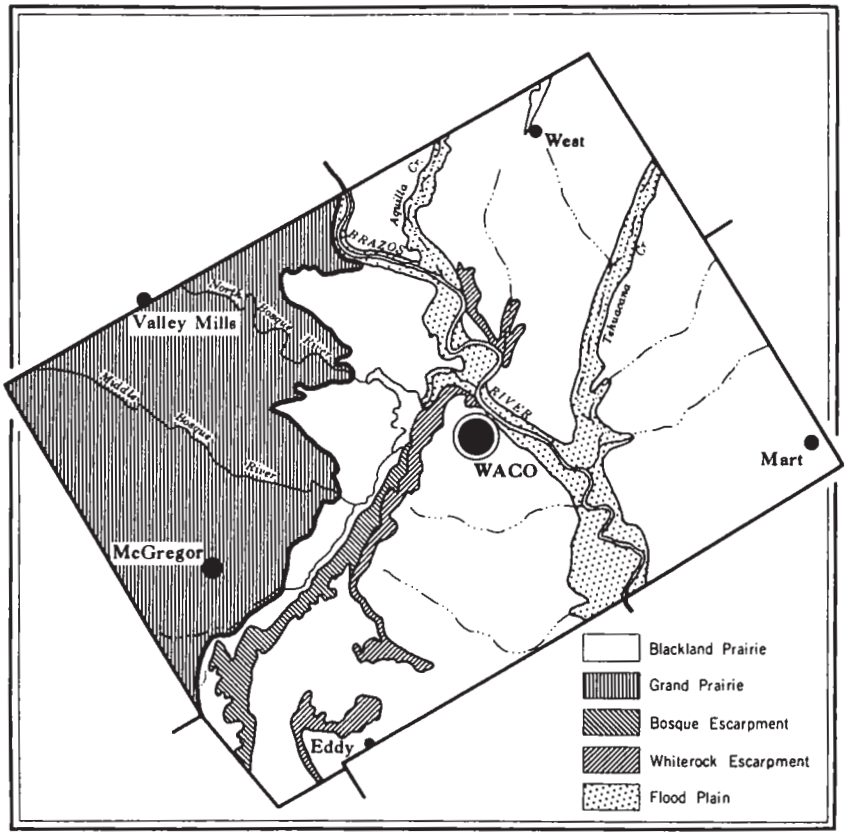

FIGURE 2.—Physiographic subdivisions of McLennan County, Tex.

county. These streams are tributaries to the Brazos River from the east. Most of them have unbalanced drainage valleys with short strong slopes on the south and long gentle slopes on the north. The larger rolling belts are along Tehuacana, Williams, Trading House, and Maness Creeks.

The canyons occur on the larger streams in the limestone country of the northwestern part of the county. Most noteworthy among these is the canyon of the Middle Bosque River, together with its extension up Bluff Creek. The narrow floor of this canyon is about 100 feet below the surrounding undulating plain and is bordered by nearly vertical bluffs of hard limestone. Downstream the canyon becomes shallower and loses identity below Crawford. Through the Grand Prairie the sides of the valleys of the Brazos and North Bosque Rivers are hilly but not precipitous.

Flanking the Brazos River and its larger tributaries are extensive flats or stream terraces. These are of two main groups: (1) Low to moderately high terraces adjacent to the present streams, with an aggregate area of about 110 square miles; and (2) remnants of old

gravelly and sandy terraces, with an aggregate area of about 50 square miles, which cap many of the higher stream divides, mainly those east of the Brazos River.

The low to moderately high terraces are at several indistinct levels. They range from low undissected benches less than 30 feet above the present flood plain to moderately high terraces. In much of the area the constructional surface of the moderately high terraces remains, but the margins are eroded and a few lines of drainage have developed. The flat that extends from Waco to Asa along the west side of the Brazos River; the bench between the Brazos River and Tehuacana Creek on which the most eastern part of Waco is built; and the low sandy terrace on the west side of the Brazos 1½ miles east of Rock Creek are the largest areas at the lower levels. The largest area of the moderately high terraces is the blackland flat. Though interrupted by the shallowly entrenched valleys of Hog Creek, the Middle Bosque River, and Harris Creek, it extends along the north side of Lake Waco and the South Bosque River from Speegleville to a point 3 miles southwest of South Bosque School. Other extensive areas are between the North Bosque and Brazos Rivers in the vicinity of Bosqueville and along the west side of Tehuacana Creek in the vicinities of Concord and Leroy.

The largest areas of the old gravelly and sandy terraces are on the divide between Aquilla Creek and the Brazos River near Gholson School, on the divide between Aquilla and Tehuacana Creeks near Tokio and Ross, and on the divide between Tehuacana and Williams Creeks near Axtell. Smaller areas are at Robinson, Rosenthal, Golindo, and Riesel. In all of these areas of terraces, the constructional surface has been entirely destroyed and the relief is that of old upland.

Topographic maps of parts of the county published by the United States Geological Survey and Texas Reclamation Department indicate that elevations above sea level in the county range from about 350 feet on the flood plain of the Brazos River at the Falls County line to about 950 feet on the higher stream divides in the northwestern part of the county.

VEGETATION[3]

Some 875 square miles of the county is prairie, which before cultivation was occupied largely by tall grasses. Little bluestem (*Andropogon scoparius*) was the principal species; big bluestem (*A. gerardi*) and Indiangrass (*Sorghastrum nutans*) were other important species. The prairie embraced all areas of dark-colored soils except those of the flood plains. Most of the prairie is now in cultivation. In most areas that remain unplowed the vegetation has been greatly altered by heavy grazing.

Native pastures in the Blackland Prairie are now mostly a mixture of short grasses and unpalatable weeds surmounted by a brushy overstory of small mesquite trees. The main grass species in these pastures are buffalo (*Buchloe dactyloides*), Texas needle (*Stipa leucotricha*), three-awn (*Aristida* spp.), and hairy grama (*Bouteloua hirsuta*).

[3] Plants in this section were identified by comparison with specimens identified by V. L. Cory, range botanist, Texas Agricultural Experiment Station.

Early settlers report that except along the drainageways, where there were a few hackberry and elm, the prairie originally was free of trees or brush. Mesquite has since invaded many pastures. Field notes for some of the earliest land surveys, made before 1840, mention large mesquite trees, so it is evident that some mesquite was present when white men first reached the area.

Native pastures in the Grand Prairie are largely restricted to stony and shallow soils less than 12 inches deep over limestone. Here the principal grasses are buffalo, hairy grama, Texas grama (*Bouteloua rigidiseta*), three-awn, and side-oats grama (*B. curtipendula*). Some little bluestem remains in the less heavily grazed places. Buffalograss is most abundant on the deeper soils. A few live-oak trees are scattered throughout many of the areas. Rough stony land, Brackett soil material, supports Spanish oak (*Quercus texana*), shinnery white oak (*Q. breviloba*), ash, redbud, and various other small trees and shrubs together with some grass. Where the limestones are soft or chalky, some of the rougher areas are covered with an almost solid stand of white cedar; similarly, the larger areas of chalk outcrop in the Blackland Prairie are in cedar brakes.

About 65 square miles originally supported post oak savannah vegetation. The main areas were largely of post oak and blackjack oak but included small proportions of elm and hickory. These corresponded to the areas of light-colored sandy soils, the larger of which are east of the Brazos River in the vicinities of Gholson School, Tokio, Ross, Elm Mott, Lakeview, Axtell, and Harrison and along the north side of Trading House Creek. Smaller areas occur west of the Brazos River near Patrick, Bosqueville, Robinson, Rosenthal, and Golindo. A somewhat different type of upland oak forest occupied the sandy soils of the lower terraces along the Brazos River, such as the Bastrop fine sandy loams. In the remaining uncleared areas of these soils, the forest is more vigorous and includes much red oak and some live oak.

The flood plains were forested with types that varied according to drainage conditions. In the bottoms of streams that drain areas of Blackland Prairie, such as Tehuacana and Aquilla Creeks, floods are frequent and drainage is slow. Here the remaining timber is largely elm and hackberry. On fertile soils of the flood plains that have free underdrainage, such as those covering most of the bottoms along the Brazos and Bosque Rivers, the forest consisted mainly of pecan, bur oak, American elm, and live oak. In very sandy parts of the Brazos River bottoms, cottonwood is the principal tree.

CLIMATE

McLennan County has a warm-temperate humid continental climate. The summers are long, with rather high temperatures much of the time. The winters are short and mild. Occasional cold spells usually last less than a week and are succeeded by periods of cool pleasant weather. In only two months, January and February, is there much freezing weather. Climatic data from the United States Weather Bureau station at Waco are given in table 2.

TABLE 2.—*Normal monthly, seasonal, and annual temperatures and precipitation at Waco, McLennan County, Tex.*

[ELEVATION, 500 FEET]

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Total for the driest year	Total for the wettest year	Average snowfall
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	50. 2	86	13	2. 74	[3]	5. 61	0. 5
January	47. 3	90	−1	2. 38	0. 49	1. 61	. 5
February	51. 8	95	−5	2. 63	. 36	3. 93	. 7
Winter	49. 7	95	−5	7. 75	. 85	11. 15	1. 7
March	58. 4	99	18	2. 94	1. 11	8. 38	. 1
April	66. 8	100	32	3. 97	2. 47	13. 01	0
May	74. 5	101	38	4. 15	4. 04	8. 39	0
Spring	66. 6	101	18	11. 06	7. 62	29. 78	. 1
June	81. 8	105	52	3. 19	. 45	5. 40	0
July	85. 0	107	61	1. 94	1. 46	3. 19	0
August	85. 5	109	54	1. 38	. 11	2. 22	0
Summer	84. 1	109	52	6. 51	2. 02	10. 81	0
September	78. 9	102	43	2. 97	1. 55	2. 74	0
October	69. 4	99	29	2. 41	. 06	2. 39	0
November	57. 8	89	19	2. 25	1. 29	3. 33	[3]
Fall	68. 7	102	19	7. 63	2. 90	8. 46	0
Year	67. 3	109	−5	32. 95	[4] 13. 39	[5] 60. 20	1. 8

[1] Average temperature based on a 72-year record, 1882 to 1953; highest and lowest temperatures from a 43-year record, 1888 to 1930.

[2] Average precipitation based on a 73-year record, 1881 to 1953; wettest and driest years based on a 65-year record, 1889 to 1953; snowfall on a 35-year record, 1896 to 1930.

[3] Trace.

[4] In 1917.

[5] In 1905.

McLennan County lies toward the western edge of the humid region. Occasional rainless periods of several months occur. Generally, however, enough rain falls to permit good growth of such crops as cotton and sorghums. Corn yields are frequently limited by low or poorly distributed rainfall. In some years rainfall is unusually high and difficulty is met in working the land and in spring planting on the more slowly drained soils. The moderate rainfall in fall and winter, when evaporation is low, enables the soils to absorb and store a large supply of moisture.

March, April, May, and June are ordinarily the months of greatest rainfall. Hence, particularly when contour cultivation that conserves

moisture is practiced, the moisture supply is usually adequate for good yields of adapted crops. Following the heavier rainfall period of late spring and early summer, there usually is a dry period in midsummer and a resumption of rains in September. Occasional rains of high intensity occur and are the main cause of erosion on unprotected land.

The average date of the last killing frost is March 10, and the average date of the first in fall is November 17. The average frost-free season is 251 days. The latest recorded in spring is April 9, and the earliest in fall is October 22. Winter temperatures are such that frost-hardy crops, such as winter legumes, hardy vegetables, and small grains, continue growth through the winter. Work in the fields is common at all seasons. Hailstones sometimes occur and damage crops in small areas.

ORGANIZATION AND POPULATION

Permanent settlement by white men in the area now in McLennan County began with the establishment of a trading post near the mouth of Tehuacana Creek in 1842. Private ownership of land began in 1832 with the survey of the T. J. Chambers grant, which includes the south half of Waco. By 1836 all of the area below Waco and within a distance of 10 miles from the Brazos River had been granted by the Republic of Mexico to individuals in tracts of several thousand acres each. Stockmen started moving into the area about 1845 when Neil McLennan, for whom the county is named, established a ranch headquarters on the South Bosque River west of Waco.

Prior to white settlement the principal inhabitants were Waco Indians. Their village stood on the present site of downtown Waco. A related tribe, the Tehuacanas, had a village near the mouth of Tehuacana Creek. Some clashes between Indians and the white settlers occurred in the early years; by 1850 the Indians had been driven out of the area.

Settlement proceeded rapidly after 1845. Most of the early settlers were native-born whites from southern States. Negro slaves were brought by some settlers and numbered over a thousand in the county in 1850. Waco was laid out in 1849. Located at a good spring on high ground next to a favored crossing of the Brazos River on the main route of travel from San Antonio and Austin to north Texas, it was soon a thriving community.

McLennan County was organized in 1850 out of parts of Milano and Robertson Counties. The first bridge across the Brazos River, the suspension bridge at Waco that is still in use, was completed in 1870. Railroads reached Waco in 1881, and Baylor University was established in 1885. The United States censuses show a gradual increase in population of the county from 6,206 in 1860 to 130,194 in 1950.

Except in the stony parts of the Grand Prairie, where inhabitants are few, the farm population is rather evenly distributed throughout the county.

Waco is the county seat and principal city. The 1950 census reported its population as 84,706. For the same year the reported population of other incorporated places was: Mart, 2,269; McGregor, 2,669; West, 2,130; Moody, 1,084; and Crawford, 423.

TRANSPORTATION AND MARKETS

Lines of four main railway systems—Missouri-Kansas-Texas, Santa Fe, Southern Pacific, and Missouri Pacific—serve the county. Nine lines radiate from Waco; the Santa Fe crosses the western part of the county. No farm is more than 15 miles from a shipping point and few are more than 10 miles. Similarly, eight hard-surfaced highways of the Federal and State systems radiate from Waco, and another runs north-south through McGregor. The county roads, on the whole, are improved and well maintained. Most of the mileage is gravelled but some is hard surfaced. In 1950 there were 1,327 farms located on hard-surfaced roads and 1,985 on gravel, shell, or shale roads.

Waco is the principal local market for farm products, but all of the larger rural centers have markets for cotton, grain, poultry, and dairy products. Fort Worth is the principal market for livestock, though many animals are sold and slaughtered in Waco.

FARM IMPROVEMENTS

Many of the farms operated by owners have well-improved farm buildings equipped with electricity, running water, and other modern conveniences, but on other farms living conditions are less favorable. In 1950, 1,407 farms were reported as having telephones, and 3,331 as having electricity. There were 1,275 motortrucks on 1,085 farms, 4,063 automobiles on 3,075 farms, and 3,323 tractors on 2,453 farms. In much of the Blackland Prairie section, water cannot be obtained from wells of practical depths and the farmers depend on cisterns and stock tanks for water.

INDUSTRIES

The principal industries of the county are centered in Waco. Located here are two main railroad shops, one of the largest lumber mills in the State, a cotton textile mill, and numerous smaller industries. A large Portland cement factory is midway between Waco and McGregor. An additional cotton textile mill is at West. There is a small oilfield, known as the South Bosque pool, 8 miles west of Waco.

AGRICULTURE

AGRICULTURAL HISTORY

Until white men settled in the area agriculture was almost nonexistent. The Waco Indians are reported to have grown corn and peaches near Waco. The cultivated areas evidently were small and restricted to sandy soils on low terraces or on the flood plain along the Brazos River.

The early white settlers were primarily stockmen who grazed cattle on the open range. Extensive cattle ranching began about 1850 and continued as the principal type of agriculture on the prairies until about 1880. In early times the range cattle were the so-called Texas longhorns, unimproved stock originating from cattle brought to North America by the Spaniards. Soon after the Civil War several stockmen introduced Red Devon bulls for improvement of their herds; these were soon followed by Shorthorns, then known as Durhams.

The first Herefords apparently were introduced shortly before 1880, and within a few years this breed had supplanted all others for improvement of range cattle. Since 1930 herds of Aberdeen Angus have been established on a few ranches.

The sandy uplands and bottoms were the first to be cultivated. In early times the prairies were generally considered unfit for farming, probably because of the distance from wood and water and the want of implements suitable for tillage of the very clayey soils. Corn, cotton, and wheat were the principal crops. Prior to the Civil War considerable acreages, particularly in the Brazos River bottoms, were farmed by slave labor.

Since the beginning of agriculture in the area, there has been a marked contrast in the type or system of farming used on the Blackland and Grand Prairies. Since about 1900 cotton has been the dominant crop on the Blackland Prairie. At various times, notably in the early twenties, cotton has occupied as much as 80 percent of the cultivated land on this prairie. There is a much higher percentage of cropland in the Blackland Prairie than in the Grand Prairie. Until about 1925, approximately 75 percent of the Blackland Prairie was cultivated. The principal reduction in the acreage of cultivated land in the county has occurred in the Blackland Prairie section.

The Grand Prairie has been principally a ranching and stock-farming section. Except in local areas like that in the vicinity of McGregor, agriculture centers around cattle and sheep raising. In the Grand Prairie as a whole, probably no more than about 50 percent of the land has ever been cultivated. Small grains and feed crops have been the important crops. During some years they have occupied as much as 70 percent of the cultivated area. Cotton has always been of minor importance and has declined in importance since about 1920. In 1940 about 45 percent of the Grand Prairie section of the county was in cultivation. At least one-half of the area in this geographic subdivision probably will always be used for grazing.

Following the construction of railways into the county in 1881 and the introduction of barbed wire for fencing, the prairies were rapidly placed in cultivation. By 1900 most of the area well suited to crops was cultivated. At that time the area of cropland was approximately 50 percent of the area. Thereafter the area of cropland increased more slowly until about 1925, when a maximum of approximately 460,000 acres was reached. Since 1925 the acreage in cultivation has decreased considerably; the census reports 316,883 acres used for crops in 1939, and 304,116 acres in 1949. Although some of the reduction in acreage is accounted for by temporary withholding of good land from production, much of the decrease was the result of retirement of areas of low productivity or areas so sloping and eroded that control of erosion under cultivation had become hardly feasible.

CROPS

Cotton is the principal crop of the county. Corn is the most important feed crop. The principal small grains are oats and winter wheat. The acreage of sorghums, including both grain and forage types, was relatively small before 1929 but has since been increasing. The principal hay crops are sorgo, small grains cut green, millet,

sudangrass, and prairie grasses cut from native meadows. Alfalfa is the most extensive of the legumes used for hay. It is almost restricted to well-drained bottom land, such as that along the Brazos and North Bosque Rivers. Cowpeas, peanuts, and soybeans occupy very small acreages.

Near Waco small areas, some of which are irrigated from wells, are in market gardens that supply some fresh vegetables for local markets. Good yields and quality are reported for a wide variety of vegetables. Peaches are the principal fruit produced for sale. Most of the orchards are small. They are concentrated in the sandy area on the low terrace of the Brazos River immediately east of Waco. Blackberries and dewberries are the principal small fruits.

The acreage of the principal crops and number of fruit trees and pecan trees in the county is given in table 3 for stated years.

TABLE 3.—*Acreage of principal crops and number of fruit trees, pecan trees, and grapevines of bearing age in McLennan County, Tex., in stated years*

Crop	1919	1929	1939	1949
	Acres	*Acres*	*Acres*	*Acres*
Cotton	234, 730	272, 896	139, 637	146, 482
Corn for all purposes	53, 120	60, 709	90, 720	48, 681
For grain	(1)	60, 082	89, 322	47, 555
Oats threshed	66, 847	46, 962	38, 844	50, 122
Wheat threshed	27, 392	8, 506	[2] 3, 913	8, 930
Barley threshed	1, 224	676	393	813
Sorghum for grain	(1)	1, 281	2, 903	8, 086
All hay	7, 019	6, 756	18, 053	18, 514
Alfalfa	(1)	887	946	1, 888
Clover and timothy, alone or mixed	(1)	54	32	680
Small grains cut for hay	2, 825	1, 069	307	1, 805
Annual legumes saved for hay	81	148	284	44
Other tame hay	2, 963	3, 640	15, 115	13, 243
Wild hay	1, 150	958	1, 369	854
Silage crops	952	20	2, 449	1, 359
Corn cut for forage	317	607	1, 185	878
Sorghums for silage, hay, or fodder	7, 762	13, 666	16, 753	12, 306
Potatoes	218	287	363	[3] 42
Sweetpotatoes	193	121	145	36
Vegetables harvested for sale	447	725	856	1, 001
Blackberries and dewberries	55	50	52	9
	Number	*Number*	*Number*	*Number*
Apple trees	187	211	54	114
Cherry do	(1)	125	111	21
Peach do	36, 981	47, 240	48, 766	18, 499
Pear do	5, 745	1, 782	1, 333	2, 302
Plum and prune do	2, 170	10, 654	8, 590	2, 702
Pecan do	(1)	13, 513	20, 779	13, 299
Fig do	274	2, 539	2, 466	1, 519
Grapevines	369	3, 759	1, 178	342

[1] Not reported.
[2] Winter wheat only.
[3] Does not include acres for farms with less than 15 bushels harvested.

NUMBER AND SIZE OF FARMS AND FARM TENURE

The 1950 census reported 557,479 acres, or 84.2 percent of the county, in farms. The number of farms was 3,754, and the average size was 148 acres. Approximately 65 percent of the farms were operated by owners, 34 percent by tenants, and less than 1 percent by managers. Practically all leases are on a crop-share basis; the landlord receives one-third of the feed crops and one-fourth of the cotton. During the 30 years since 1920, the trend has been toward fewer and larger farms.

SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists of examining, classifying, and mapping of soils in the field. The soil scientist walks over the area at intervals varying with the complexity of the landscape. Generally, the intervals are not more than one-quarter mile apart. He bores into the soil with an auger or digs holes with a spade. Each such boring or hole shows the soil to consist of several distinctly different layers, called horizons, which collectively are known as the soil profile. Each of these layers is studied for the things about it that affect plant growth.

The color of each layer is noted. There is usually a relationship between the darkness of the topmost layer of soil and its content of organic matter; streaks and spots of gray, yellow, and brown in lower layers generally indicate poor drainage and poor aeration.

Texture—the relative proportions of sand, silt, and clay—is judged by rubbing the soil between the fingers and is later checked by mechanical analyses in the laboratory. Texture determines to a considerable extent the quantity of moisture the soil will hold available to plants, whether plant nutrients or fertilizers will be held by the soil in forms available to plants or will be leached out, and the difficulty or ease of cultivating the soil.

Soil structure and porosity determine the permeability or perviousness of the soil and, consequently, the ease with which water and plant roots penetrate it.

Consistence, or the tendency of the soil to crumble or to stick together, determines the degree of difficulty that will be encountered in keeping the soil open and porous under cultivation. Consistence covers such soil characteristics as hardness, friability, plasticity, stickiness, compactness, toughness, and cementation.

Surface soil refers to the uppermost part of the soil to a depth ordinarily disturbed by tillage, usually about 7 inches. The material immediately below the surface soil is subsoil; that below the principal zone of rooting by plants, commonly below 3 to 6 feet, is substratum.

The kinds of rocks and the parent soil material that develops from these rocks affect the quantity and kind of plant nutrients in the soil. Simple chemical tests are made to show the degree of acidity of the soil. Depth to bedrock or to compact layers is determined. The quantity of gravel or rocks that may interfere with cultivation, the steepness and kind of slope, the apparent modification of the soil by erosion, and other features are noted and evaluated.

On the basis of all the characteristics here listed, soil areas much alike in the kind, thickness, and arrangement of layers are mapped

as one soil type. Some soil types are subdivided into two or more phases. The subdivision of a soil type into phases is based on differences other than in kind, thickness, and arrangement of the soil layers. A soil may be divided into phases because of slope, frequency of outcropping bedrock, the extent of erosion, or the artificial drainage used. For instance, a soil type that occurs on slopes ranging from 1 to 15 percent may be subdivided into three phases, the first on slopes of 1 to 4 percent, the second on slopes of 4 to 8 percent, and the third on slopes of 8 to 15 percent.

Two or more soil types similar in subsoil and substratum, but different in surface texture, make up a soil series. A soil series therefore consists of one or more soil types that are—except for texture of the surface layer—about the same in kind, thickness, and arrangement of layers.

The name of the place near where a soil was first defined is chosen as the name of the series. Thus, Axtell is the name of light-colored, acid, forested soils, with a claypan subsoil, that were first identified near Axtell. The soils developed in calcareous or alkaline alluvial deposits on old very high terraces along the Brazos River Valley in McLennan County. Two types of the Axtell series are mapped in the county—Axtell fine sandy loam, and Axtell very fine sandy loam. These soil types have a different surface soil texture, as their names indicate.

When very small areas of two or more kinds of soil are so intricately mixed that they cannot be shown separately on a map of the scale used, they are mapped together, and the areas of the mixture are given a compound name. Thus, the mixture, or complex, of Austin gravelly clay loam and Eddy gravelly clay loam in McLennan County is called Austin-Eddy gravelly clay loams.

Areas that have little true soil are given descriptive names. Examples are Riverwash, Rough broken land, and Rough stony land.

The soil type, or where the soil type is subdivided, the soil phase, is the unit of mapping in soil surveys. It is the unit, or kind, of soil area that is most nearly uniform and has the narrowest range of characteristics. For this reason, land use and soil management practices can be more definitely specified for it than for broader groups of soils that contain more variation. One can say, for example, that soils of the Houston series are suited to production of all the field crops common to the area. But for Houston clay, 1 to 4 percent slopes, statements can be more specific. This phase is only moderately susceptible to erosion under cultivation and can be used satisfactorily in a cropping system in which row crops dominate. In contrast, Houston clay, 4 to 8 percent slopes, is a soil phase very susceptible to erosion under cultivation and therefore requires a cropping system in which broadcast crops are dominant. Houston clay, 8 to 15 percent slopes, is a phase so susceptible to erosion under cultivation that it is considered unsuitable for tillage and is best suited to permanent grass pastures.

A more complete discussion of soil survey methods and more specific definitions of the special terms used in describing soils are given in the Soil Survey Manual.[3] Except where "moist" is specified, all color descriptions in this report are for the soil when dry.

[3] UNITED STATES DEPARTMENT OF AGRICULTURE. SOIL SURVEY MANUAL. U. S. Dept. Agr. Handbook 18, 503 pp., illus. 1951.

SOILS OF McLENNAN COUNTY, TEXAS

PRINCIPAL SOIL AREAS AND THEIR USE

The principal soil areas of the county are shown in figure 3. In each of these general areas are a few closely related soils that formed in similar parent materials and have comparable relief and native vegetation.

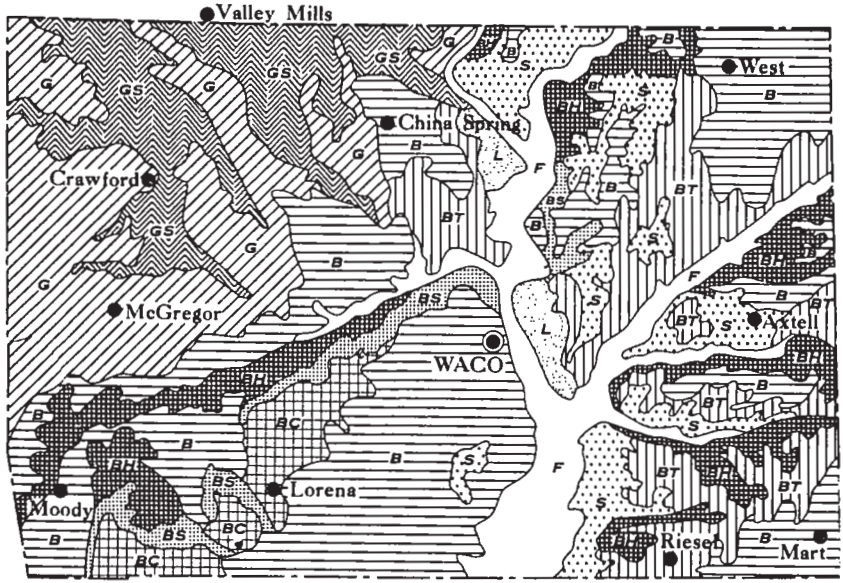

FIGURE 3.—General soil areas of McLennan County, Tex. BLACKLAND PRAIRIE: *B*, Deep crumbly blackland; *BH*, brown and yellow clay hills; *BC*, mixed shallow and deep clays on chalk; *BS*, chalk hills; *BT*, tight prairie. GRAND PRAIRIE: *G*, mixed shallow and deep clays on limestone; *GS*, stony and rough lands on limestone. OTHER PRINCIPAL SOIL AREAS: *S*, sandy forested uplands; *L*, brown loamy soils of Brazos River benches; *F*, flood plains.

BLACKLAND PRAIRIE

The Blackland Prairie portion of McLennan County is underlain by marls, calcareous clays, and chalks. It is well suited to crop production and supports a rather intensive agriculture based mainly on cotton. The most extensive and characteristic soil is the deep, dark-colored, limy clay of broad undulating areas—Houston Black clay. But there are large areas of other soils not quite so favorable for farming. Five subdivisions are indicated: (1) Deep crumbly blackland; (2) brown and yellow clay hills; (3) mixed shallow and deep clays on chalk; (4) chalk hills; and (5) tight prairie.

Deep crumbly blackland.—This subdivision of the Blackland Prairie comprises gently rolling to nearly level areas of prairie underlain by marl or highly calcareous clay. It is very largely of fertile deep limy heavy but crumbly clay. The principal soils are the Houston Black clays; others that are extensive in certain localities are Bell clays, Lewisville clays, Austin silty clays, and Houston clay, 1 to 4 percent slopes. All of these are well suited to farming.

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The largest area of deep crumbly blackland extends southward from Waco and reaches from the Missouri-Kansas-Texas Railroad on the west to the Brazos bottoms on the east; other large areas are near West, Mart, Moody, Spring Valley, Speegleville, and China Spring. All areas are largely in cultivation. The cropping system consists of cotton alternated with small grains, corn, or grain sorghums. On these clays, small grains generally produce less feed than corn or sorghums and occupy relatively small acreages. The long-time average yields of small grains are somewhat reduced by occasional lodging or by the loss that occurs when wet fields delay harvesting. No legume or hay crop is extensively grown. So few livestock are kept that practically no manure is available for application to the fields. Most fields are rather strongly infested with the organism that causes cotton root rot. Under prevailing management the soil fertility and crop yields are gradually declining.

Brown and yellow clay hills.—This subdivision comprises moderately to strongly rolling areas of prairie underlain by marl or highly calcareous clay. The principal soil is Houston clay, 4 to 8 percent slopes; others of considerable extent are Austin silty clay, 4 to 8 percent slopes; Houston clay, 8 to 15 percent slopes; and Sumter clay, 8 to 20 percent slopes. The first two are naturally fertile soils that are suited to crops, but they require careful management to prevent erosion and need a cropping system in which broadcast, erosion-resistant crops are dominant. The last two are so sloping or eroded they are not suitable for cropping.

Although a considerable extent of the steeper areas remains in native pasture, until very recently the brown and yellow clay hills have been used mainly for cotton farming. As a result of this use, much soil erosion and lessening of fertility has occurred. Many formerly productive fields have become unproductive and have been retired from cultivation. Cotton farming still prevails in much of the area, but the trend toward livestock farming is rather strong. Under a system of livestock farming, the steeper lands are in permanent pasture and the fields are occupied much of the time by feed crops, which afford better protection than cotton against soil washing.

Mixed shallow and deep clays on chalk.—This subdivision is a belt of undulating prairie that extends southward from a point 3 miles west of Waco past Lorena and Eddy into Bell County. The belt is bordered on the west and interrupted along North Cow Bayou and South Cow Bayou by chalk hills. The most extensive soil is Austin silty clay, shallow variant, which is only moderately fertile and somewhat droughty. Small grains produce better on this soil than most row crops and generally occupy a large proportion of the cropland. Associated with this soil are many small knolls of Austin-Eddy gravelly clay loams and valleys of deeper soils (Houston Black clays). The corn and cotton grown in this section are mainly on the deeper soils. Many farms have a considerable proportion of soil too shallow for crops, and the prevailing agriculture depends on a combination of small grains, livestock, and cotton.

Chalk hills.—This subdivision comprises moderately to strongly sloping areas of thin soils on chalk. Most of the areas are unfit for crops and best suited to pasture. The principal soil type is Eddy

gravelly clay loam, which is nonarable. There are minor areas of somewhat deeper soils, such as the shallow variant of Austin silty clay, that have limited suitability as cropland. The chalk hills are mostly in native pasture. Because of erosion and low fertility, the large areas once cultivated are now in forage crops or in abandoned-field pastures that afford sparse grazing.

Tight prairie.—This subdivision comprises general areas of level to undulating relief but includes many small areas that are moderately to strongly rolling. It consists mainly of gray to grayish-brown noncalcareous crusty soils with very compact subsoils of heavy clay. The largest area is an undulating prairie mainly occupied by Wilson clay loams in southeastern McLennan County around Riesel and Battle. The other principal areas are old stream terraces and consist largely of Irving soils. For the most part, all these soils are nearly level and too slowly drained to produce good yields of corn. The area of tight prairie between Bosqueville and Erath is very gently undulating and largely of Payne clay loam, 1 to 2 percent slopes. The agriculture in the general areas of tight prairie is cotton farming, or essentially the same as that prevailing on the deep crumbly blackland. The average crop yields, however, are less. Sorghums and small grains tend to replace corn as the principal feed crops.

GRAND PRAIRIE

The part of the county in the Grand Prairie is occupied by a mixture of shallow and stony clays intermingled with areas of deep, dark-colored, fertile clays. The arable lands are very largely in cultivation. They are used mainly for small grains and cotton, and to considerable extent for corn and grain sorghums. The nonarable lands support nutritious native grasses and are used as pasture, mainly for beef cattle.

Mixed deep and shallow clays on limestone.—These general soil areas comprise the farming sections of the Grand Prairie. They consist of undulating prairie underlain by rather soft limestones intermixed with some marl. The prevailing soils are reddish-brown to black crumbly clays of the Denton, San Saba, Tarrant, and Crawford series. Depth of soil over bedrock is variable. Most farms include some thin but arable soil on which small grains produce better than other crops, some deep soil on which cotton and corn give good yields, and some stony nonarable land that can be used only for pasture. Certain localities, such as the section east and southeast of McGregor, consist almost entirely of deep soils and support agriculture like that prevailing on the deep crumbly soils of the Blackland Prairie. The agriculture of the general areas of mixed deep and shallow clays on limestone is supported by livestock and two cash crops, cotton and small grains. The importance of livestock and small grains increases with the proportionate extent of shallow soil.

Stony and rough lands on limestone.—The stony and rough lands are largely nonarable and are used for stock farming or ranching. The principal soil type is Tarrant stony clay. It is nonarable but is naturally adapted to and moderately productive of native grasses. Soils suitable for cultivation comprise not more than one-fifth of the total area of this subdivision, and much of this is in bodies too small

to form convenient fields. The areas suitable for cultivation are used mainly to produce the oats, sorghums, and corn needed for feeding livestock. Raising of beef cattle and sheep dominates in the agriculture.

OTHER PRINCIPAL SOIL AREAS

Sandy forested uplands.—These are isolated areas on old stream terraces within the Blackland Prairie. The soils are light colored, acid, and relatively infertile. They are similar to those that prevail in the post-oak belt of eastern Texas. The three largest areas are located as follows: (1) north of Gholson, (2) near Ross and Tokio, and (3) in the vicinity of Axtell. These gently rolling areas are underlain by noncalcareous sands and clays intermixed with much quartzitic gravel. Other areas at lower elevations, which are partly level and partly gently rolling, occur 1 mile southeast of Elm Mott; along the north side of Trading House Creek, southward from Harrison; and near Lakeview, Patrick, Bosqueville, Robinson, Rosenthal, and Golindo. These soils are used chiefly for cotton, corn, and sorghum. They are usually quite acid and low in fertility. Some areas are still in native post oak and are used for grazing. Yields of crops are usually low.

Axtell fine sandy loam is the principal soil type in most areas of the sandy forested uplands. This soil has a 5- to 12-inch sandy surface layer over dense tough clay, which is a claypan subsoil. It has low fertility and very slow internal drainage and is rather droughty. Some areas are cropped but produce low yields; many areas formerly cropped have been retired to pasture or are idle. The principal field crops are cotton and corn. Desirable pasture grasses can be grown under good management that includes proper fertilization. Nevertheless, the pastures are generally of low carrying capacity and poor quality.

The areas of sandy timbered upland near Lakeview, Robinson, and Golindo include large proportions of fine sandy loams of the Milam, Sawyer, and Travis series. These soils have sandy layers 12 to 24 inches deep over subsoils of clay or sandy clay. Although of rather low natural fertility, they have favorable physical characteristics, respond well to fertilizers, and are particularly suited to such special crops as peanuts, sweetpotatoes, and vegetables and fruits. Near Gholson School an area of about 4 square miles is occupied mainly by deep loose fine sand of the Eufaula series. This area is suitable for certain special crops but requires intensive management to maintain fertility and to prevent soil blowing.

Brown loamy soils of the Brazos River benches.—These soils are on level areas or low terraces adjacent to the Brazos River flood plain and are of the Bastrop and Vanoss series. The underlying parent materials are calcareous sands and silts. The soils combine moderate fertility with very favorable physical characteristics and are well suited to nearly any crop adapted to the climate. Considerable acreages are used for the vegetables and tree fruits grown to supply the Waco market; others are used for cotton, corn, and other field crops.

Flood plains.—These are areas of alluvial soils consisting of recent sediments dropped by floodwaters. Except for a few tracts of loose

sand immediately adjacent to the Brazos River, the soils of the first bottoms are very fertile and highly productive wherever drainage is adequate. Much of the area along the Brazos River consists of brown silty soils with free underdrainage and only moderate flood hazard. These, which are of the Norwood and Asa series, probably are the most productive soils in the county. Corn yields are reported to be higher than elsewhere, alfalfa thrives, and all crops adapted to the climate produce well.

The first bottoms along prairie streams flowing into the Brazos River from the east are largely of Trinity clay. This is a heavy clay that has slow internal drainage and is subject to frequent flooding. Many areas are successfully farmed, mainly for cotton and corn, but in some places the flood hazard is so severe that the soil is used for pasture. Most of the first bottoms along the streams in the western part of the county are Catalpa soils. These soils have moderately free internal drainage and are flooded less frequently than the Trinity clay. Nearly all areas large enough to form convenient fields are in cultivation and produce good yields of cotton, corn, alfalfa, and other field crops.

ESTIMATED ACREAGES BY GEOGRAPHIC SUBDIVISIONS

The estimated acreages of arable soils, nonarable soils, and urban areas and farmsteads, by geographic subdivisions, are given in table 4.

TABLE 4.—*Estimated acreages of arable soils, nonarable soils, and urban areas and farmsteads in McLennan County, Tex., by geographic subdivisions*

Land areas	Blackland Prairie section			Grand Prairie	Total
	Blackland Prairie proper	Brazos River bottoms [1]	Sandy forested upland		
Land other than urban areas and farmsteads:					
Arable soils—	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Well suited as cropland	254, 100	29, 400	-------	65, 200	348, 700
Marginal or limited suitability as cropland	95, 000	6, 200	36, 000	46, 200	183, 400
Total acreage of arable soils	349, 100	35, 600	36, 000	111, 400	532, 100
Nonarable soils	37, 600	4, 900	-------	53, 300	95, 800
Acreage of arable and nonarable soils	386, 700	40, 500	36, 000	164, 700	627, 900
Urban areas and farmsteads	13, 000	4, 100	700	13, 700	31, 500
Total acreage [2]	399, 700	44, 600	36, 700	178, 400	[2] 659, 400

[1] Consist of the flood plain of the Brazos River and border low terraces occupied by Bastrop, Brewer, and Vanoss soils.

[2] Does not include 6,600 acres of water area (Blackland Prairie, 3,800 acres; Brazos River bottoms, 2,700; and Grand Prairie, 100).

KEY TO THE SOILS OF McLENNAN COUNTY, TEX.

I. SOILS OF UPLAND PRAIRIES UNDERLAIN BY MARL, CHALK, CLAY, OR LIMESTONE GRAVEL; SOILS OF THE BLACKLAND PRAIRIE AND DARK-COLORED STREAM TERRACES.

A. *Surface Soils Crumbly, Granular, Mostly Calcareous:*

1. Surface soils black to dark gray:

a. Underlain by marine sediments of marl, chalk, or calcareous clay. — Houston Black series.

(1) More than 30 inches deep:

(a) Gently sloping areas — Houston Black clay, 1 to 4 percent slopes. Houston Black gravelly clay, 1 to 4 percent slopes.

(b) Level areas — Houston Black clay, 0 to 1 percent slopes.

(2) Less than 30 inches deep over chalk; very gently sloping. — Houston Black clay, moderately deep variant, 1 to 4 percent slopes.

b. Underlain by old alluvial sediments of calcareous clay; soils of stream terraces:

(1) No texture profile; parent materials of sediments from the Blackland and Grand Prairies. — Bell series.

(a) Surface soil calcareous; areas level — Bell clay, 0 to 1 percent slopes.

(b) Surface soil calcareous; areas gently sloping. — Bell clay, 1 to 4 percent slopes.

(c) Surface soil noncalcareous; areas level — Bell clay, noncalcareous variant, 0 to 1 percent slopes.

(2) Soils with a texture profile; parent materials of mixed sediments from prairies and Red Plains; areas mostly level. — Brewer series: Brewer clay loam, 0 to 1 percent slopes.

2. Surface soils olive brown to dark yellowish brown, calcareous, moderately granular; internal drainage wanting:

a. Underlain by marine sediments of shaly marl and calcareous clay. — Houston series.

(1) Moderately sloping — Houston clay, 4 to 8 percent slopes.

(2) Gently sloping — Houston clay, 1 to 4 percent slopes.

(3) Hilly areas — Houston clay, 8 to 15 percent slopes.

3. Surface soils dark grayish brown, grayish brown, or brown; calcareous; very granular; internal drainge medium:

a. Underlain by marine sediments of friable marl or chalk. — Austin series.

(1) Soils more than 18 inches deep over marl or chalk:

(a) Gently sloping. Surface soil dark grayish brown to grayish brown; substrata light-gray marl or chalk. — Austin silty clay, 1 to 4 percent slopes.

(b) Moderately sloping. Surface soil grayish brown; substrata light-gray marl. — Austin silty clay, 4 to 8 percent slopes.

(c) Hilly. Surface soil brown or grayish brown; substrata yellow or light-gray friable marl. — Austin silty clay, 8 to 15 percent slopes.

(2) Soils 7 to 18 inches deep over chalk:	
(a) Gently sloping	Austin silty clay, shallow variant, 1 to 4 percent slopes.
(b) Moderately sloping	Austin silty clay, shallow variant, 4 to 8 percent slopes.
(3) Soils 4 to 7 inches deep over chalk; gently sloping.	Austin gravelly clay loam, 1 to 4 percent slopes.[1]
b. Underlain by alluvial sediments; soils of stream terraces:	
(1) Deep soils with substrata of calcareous clay containing little gravel.	Lewisville series.
(a) Gently sloping	Lewisville clay, 1 to 4 percent slopes. Lewisville clay loam, 1 to 4 percent slopes.
(b) Level	Lewisville clay, 0 to 1 percent slopes.
(c) Moderately sloping	Lewisville clay, 4 to 8 percent slopes. Lewisville clay loam, 4 to 8 percent slopes.
(2) Moderately shallow or shallow soils with substrata of limestone gravel within 30 inches of the surface.	Patrick series.
(a) Soil 10 to 30 inches deep over gravel beds; gently sloping.	Patrick clay, 1 to 4 percent slopes.
(b) Gravelly soil less than 10 inches deep over gravel beds; gently sloping to hilly.	Patrick gravelly clay, 2 to 15 percent slopes.
4. Surface soils light brownish gray to gray, highly calcareous, very granular:	
a. Substrata of chalk or chalky marl	Eddy series.
(1) Less than 7 inches deep over chalk:	
(a) Gently sloping	Eddy gravelly clay loam, 1 to 4 percent slopes.[2]
(b) Moderately to strongly sloping	Eddy gravelly clay loam, 4 to 15 percent slopes.
(c) Steeply sloping	Eddy gravelly clay loam, 15 to 50 percent slopes.
(2) More than 7 inches deep over chalk or chalky marl:	
(a) Surface soil light brownish gray; areas moderately to strongly sloping.	Eddy silty clay, 8 to 15 percent slopes.
5. Surface soils yellowish brown to yellow, calcareous. Areas mostly hilly; some moderately sloping, severely eroded. Underlain by marine sediments of yellow marls and calcareous clays, mostly shaly, some friable.	Sumter series: Sumter clay, 8 to 20 percent slopes.

[1] Occurs in complex with Eddy gravelly clay loam; mapped as Austin-Eddy gravelly clay loams, 1 to 4 percent slopes.

[2] Occurs in complex with Austin gravelly clay loam; mapped as Austin-Eddy gravelly clay loams, 1 to 4 percent slopes.

B. *Surface Soils Noncalcareous and Crusty, Some Weakly Granular; Subsoils of Clay, Mostly Very Compact; Tight Soils of the Grasslands:*

1. Surface soil loamy, distinctly less clayey than subsoil; soils with texture profiles:

a. Surface soils very dark gray to gray, tight, crusty; subsoils of dark-gray tough dense clay:

(1) Erosional upland; underlain by marine sediments of calcareous clays: Wilson series.

(a) Level — Wilson clay loam, 0 to 1 percent slopes.

(b) Gently sloping — Wilson clay loam, 1 to 3 percent slopes.

(c) Moderately sloping — Wilson clay loam, 3 to 8 percent slopes.[3]

(d) Strongly sloping — Wilson clay loam, 8 to 15 percent slopes.[4]

(2) Underlain by alluvial sediments of calcareous clays; soils of stream terraces. Irving series.

(a) Level — Irving fine sandy loam, 0 to 1 percent slopes.[5]

(b) Gently sloping —
- Irving clay loam, 0 to 1 percent slopes.
- Irving silt loam, 0 to 1 percent slopes.
- Irving clay loam, 1 to 3 percent slopes.
- Irving gravelly clay loam, 1 to 4 percent slopes.[6]

(c) Moderately sloping — Irving gravelly clay loam, 4 to 8 percent slopes.[7]

b. Surface soils dark grayish brown to grayish brown, crusty; subsoils of brownish or highly mottled compact clay:

(1) Areas on undulating to rolling erosional upland:

(a) Subsoils mottled reddish brown, gray, and yellowish brown:

a1. Subsoils and subtrata very gravelly; some areas forested. Riesel series.

a1a. Gently sloping —
- Riesel gravelly clay loam, 1 to 4 percent slopes.[8]
- Riesel gravelly loam, 1 to 4 percent slopes.[9]

a1b. Moderately sloping —
- Riesel gravelly clay loam, 4 to 8 percent slopes.[10]
- Riesel gravelly loam, 4 to 8 percent slopes.[11]

[3] Occurs in complex with Houston clay; mapped as Wilson-Houston complex, 3 to 8 percent slopes.
[4] Occurs in complex with Houston clay; mapped as Wilson-Houston complex, 8 to 15 percent slopes.
[5] Occurs in complexes with Axtell and Ivanhoe soils; mapped as Irving-Axtell complex, 0 to 1 percent slopes, and as Ivanhoe-Irving-Axtell complex, 0 to 1 percent slopes.
[6] Occurs in complex with Riesel gravelly clay loam; mapped as Riesel-Irving gravelly clay loams, 1 to 4 percent slopes.
[7] Occurs in complex with Riesel gravelly clay loam; mapped as Riesel-Irving gravelly clay loams, 4 to 8 percent slopes.
[8] Occurs in complex with Irving gravelly clay loam; mapped as Riesel-Irving gravelly clay loams, 1 to 4 percent slopes.
[9] Occurs in complex with Axtell gravelly loams; mapped as Riesel-Axtell gravelly loams, 1 to 4 percent slopes.
[10] Occurs in complex with Irving gravelly clay loam; mapped as Riesel-Irving gravelly clay loams, 4 to 8 percent slopes.
[11] Occurs in complex with Axtell soils; mapped as Riesel-Axtell gravelly loams, 4 to 8 percent slopes.

a2. Subsoils nongravelly	Crockett series.
a2a. Gently sloping	Crockett loam, 1 to 3 percent slopes.
a2b. Moderately sloping	Crockett loam, 3 to 8 percent slopes. Crockett clay loam, severely eroded, 3 to 8 percent slopes.
a2c. Hilly	Crockett loam, 8 to 15 percent slopes.
(b) Subsoils brown to grayish brown, unmottled; substrata of calcareous clay; gently sloping areas.	Payne series: Payne clay loam, 1 to 2 percent slopes.
(2) Level areas on low terraces near the Brazos River; subsoils mottled gray and brown; substrata of calcareous silty clays.	Ivanhoe series: Ivanhoe silt loam, 0 to 1 percent slopes.[12]
c. Surface soils brown to dark brown, weakly granular, only slightly crusty; subsoils of reddish-brown permeable clay; reddish brown; substrata highly calcareous and freely permeable; gently sloping.	Norge series: Norge clay loam, 1 to 4 percent slopes. Norge fine sandy loam, 1 to 4 percent slopes.
2. Surface soil clay; soils without a texture profile:	
a. Surface soil very dark gray to gray, noncalcareous, crusty; areas level to gently sloping.	Burleson series.
(1) Level	Burleson clay, 0 to 1 percent slopes.
(2) Gently sloping	Burleson clay, 1 to 3 percent slopes.[13]
b. Surface soil olive brown to olive yellow, gummy; thin soils on noncalcareous shaly clay; areas hilly to moderately sloping.	Ellis series: Ellis clay, 6 to 15 percent slopes.

II. SOILS OF THE GRAND PRAIRIE.

A. *Soils on Limestone:*

1. Surface soils dark brown to dark grayish brown, calcareous, granular:	
a. Soil more than 7 inches deep over limestone	Denton series.
(1) Soil more than 18 inches deep over limestone; areas gently sloping.	Denton clay, 1 to 4 percent slopes.
(2) Soil 7 to 18 inches deep over limestone; areas gently sloping.	Denton clay, shallow variant, 1 to 4 percent slopes.
b. Soil less than 7 inches deep over limestone; areas gently sloping to hilly.	Tarrant series: Tarrant stony clay, 1 to 8 percent slopes.
2. Surface soils black to dark gray, mostly calcareous; areas mostly level, some very gently sloping.	San Saba series.
a. Soil nonstony:	
(1) Soils more than 24 inches deep over limestone.	San Saba clay, 0 to 2 percent slopes.
(2) Soil 12 to 24 inches deep over limestone	San Saba clay, shallow variant, 0 to 1 percent slopes.
b. Soil stony; depth to limestone bedrock mostly 10 to 20 inches.	San Saba stony clay, 1 to 2 percent slopes.[14]

[12] Occurs in complex with Irving and Axtell soils; mapped as Ivanhoe-Irving-Axtell complex, 0 to 1 percent slopes.

[13] Occurs in complex with Houston clay; mapped as Burleson-Houston clays, 1 to 3 percent slopes.

[14] Occurs in complex with Crawford stony clay; mapped as San Saba-Crawford stony clays, 1 to 2 percent slopes.

3. Surface soil reddish brown to dark brown, noncalcareous, only moderately granular; areas gently sloping.	Crawford series.
a. Soils nonstony:	
(1) Soil more than 18 inches deep over limestone.	Crawford clay, 1 to 3 percent slopes.
(2) Soil less than 18 inches deep over limestone.	Crawford clay, shallow variant, 1 to 3 percent slopes.
b. Soil stony; depth to bedrock mostly 10 to 20 inches.	Crawford stony clay, 1 to 2 percent slopes.[15]
4. Surface soils gray to light brownish gray, highly calcareous, granular; shallow soils mostly on soft limestone; areas mostly hilly to steep.	Brackett series: Brackett stony clay, 8 to 20 percent slopes.[16]
B. *Soils Developed on Local Alluvium from Limestone Slopes; Surface Soils Dark Grayish Brown, Calcareous, Very Granular; Substrata Light Brown Friable Clay; Moderately Sloping Areas in Narrow Valleys.*	Krum Series: Krum clay, 4 to 8 percent slopes.
III. LIGHT-COLORED ACID SANDY SOILS OF FORESTED UPLANDS.	
A. *Sandy Loams With Mottled Subsoils of Compact Sandy Clay:*	
1. Sandy loam less than 12 inches deep over sandy clay:	
a. Subsoil mottled red, yellow, and gray; very compact and very slowly permeable.	Axtell series.
(1) Level to very gently sloping	Axtell fine sandy loam, 0 to 2 percent slopes. Axtell very fine sandy loam, 0 to 1 percent slopes.
(2) Moderately sloping	Axtell fine sandy loam, 4 to 10 percent slopes.[17]
b. Subsoil red in the upper part, mottled red, yellow and gray below; only moderately compact; areas gently to moderately sloping.	Hortman series: Hortman fine sandy loam, 2 to 4 percent slopes. Hortman fine sandy loam, 4 to 10 percent slopes.[18]
2. Sandy loam 12 to 24 inches deep over sandy clay:	
a. Subsoils yellow in the upper part, yellow mottled with gray and red below; slowly permeable; areas very gently sloping.	Sawyer series: Sawyer fine sandy loam, 0 to 1 percent slopes.
B. *Sandy Soils With Unmottled Subsoils of Firm but Moderately Permeable Sandy Clay.*	Travis series.
1. Gently sloping	Travis fine sandy loam, 1 to 4 percent slopes.
2. Moderately sloping	Travis fine sandy loam, 4 to 8 percent slopes.

[15] Occurs in complex with San Saba stony clay; mapped as San Saba-Crawford stony clays, 1 to 2 percent slopes.

[16] Occurs in complex with Tarrant stony clay; mapped as Tarrant-Brackett stony clays, 8 to 20 percent slopes.

[17] Occurs in complex with Hortman fine sandy loam; mapped as Hortman-Axtell fine sandy loams, 4 to 10 percent slopes.

[18] Occurs in complex with Axtell fine sandy loam; mapped as Hortman-Axtell fine sandy loams, 4 to 10 percent slopes.

C. *Sandy Soils With Unmottled Subsoils of Friable and Permeable Sandy Clay Loam Within 36 Inches of the Surface:*	
1. Subsoil red to yellowish red	Milam series.
a. Surface layer of light fine sandy loam 10 to 15 inches deep over heavier subsoil:	
(1) Gently sloping	Milam fine sandy loam, 1 to 4 percent slopes.
(2) Moderately sloping	Milam fine sandy loam, 4 to 8 percent slopes.
b. Surface layer of loamy fine sand 15 to 30 inches thick over heavier subsoil; areas gently sloping.	Milam loamy fine sand, 1 to 4 percent slopes.
2. Subsoil yellowish; surface layer of loamy fine sand 24 to 36 inches deep over heavier subsoil; areas nearly level.	Stidham series: Stidham loamy fine sand, 0 to 2 percent slopes.
D. *Loose Sand More Than 36 Inches Deep Over Heavier Subsoil.*	Eufaula series: Eufaula fine sand, 0 to 2 percent slopes.
IV. BROWN LOAMS OF THE BRAZOS RIVER BENCHES; REACTION OF SURFACE SOILS ABOUT NEUTRAL; SUBSOILS OF MODERATELY PERMEABLE CLAY LOAM OR SANDY CLAY LOAM.	
A. *Surface Soil Grayish Brown to Dark Grayish Brown; Subsoil Brown to Yellowish Brown; Areas Level.*	Vanoss series: Vanoss silt loam, 0 to 1 percent slopes. Vanoss fine sandy loam, 0 to 1 percent slopes.
B. *Surface Soil Brown to Grayish Brown; Subsoil Reddish Brown to Red.*	Bastrop series.
1. Level	Bastrop fine sandy loam, 0 to 1 percent slopes. Bastrop very fine sandy loam, 0 to 1 percent slopes.
2. Moderately sloping	Bastrop fine sandy loam, 4 to 8 percent slopes.
V. ALLUVIAL SOILS OF THE FLOOD PLAINS; RECENT STREAM SEDIMENTS.	
A. *Mixed Sediments From Prairies and Areas in the Brazos River Flood Plain:*	
1. Internal drainage slow; subsoils fine textured:	
a. Surface soil dark brown to dark reddish brown, calcareous; subsoil brown to reddish-brown clay; mostly areas that flood occasionally.	Miller series: Miller clay, 0 to 1 percent slopes.
b. Surface soils black, calcareous; subsoil clay, reddish brown below 24 inches; frequently flooded areas near junctions of prairie streams with the Brazos River.	Pledger series: Pledger clay, 0 to 1 percent slopes.
2. Internal drainage medium to rapid:	
a. Surface soil (brown to light reddish brown) no darker than subsoil; calcareous; occasionally flooded areas:	
(1) Subsoil of medium to moderately fine texture; internal drainage moderately rapid.	Norwood series: Norwood silt loam, 0 to 1 percent slopes. Norwood silty clay loam, 0 to 1 percent slopes.

(2) Subsoil moderately coarse textured; internal drainage rapid	Yahola series: Yahola silt loam, 0 to 1 percent slopes. Yahola very fine sandy loam, 0 to 1 percent slopes.
b. Surface soil darker than subsoil, mostly noncalcareous; high areas that flood rarely:	
(1) Subsoil texture moderately fine to medium; internal drainage free; surface soil dark brown to brown.	Asa series: Asa silt loam, 0 to 1 percent slopes. Asa silty clay loam, 0 to 1 percent slopes. Asa very fine sandy loam, 0 to 1 percent slopes.
(2) Subsoil coarse textured; internal drainage rapid; surface soil brown to light reddish brown.	Brazos series: Brazos silt loam, 0 to 1 percent slopes. Brazos loamy very fine sand, 0 to 1 percent slopes.
B *Sediments From the Prairies; Areas in Flood Plains of Streams Other Than the Brazos River:*	
1. Calcareous:	
a. Surface soil black to dark gray; internal drainage very slow; frequently flooded areas mostly along streams that drain Blackland Prairie.	Trinity series: Trinity clay, 0 to 1 percent slopes.
b. Surface soil grayish brown to dark grayish brown; internal drainage mostly medium; mainly areas along streams that drain Grand Prairie.	Catalpa series: Catalpa clay, 0 to 1 percent slopes, frequently flooded. Catalpa clay, 0 to 1 percent slopes, occasionally flooded. Catalpa clay, 1 to 4 percent slopes. Catalpa clay loam, 0 to 1 percent slopes, frequently flooded. Catalpa clay loam, 0 to 1 percent slopes, occasionally flooded. Catalpa clay loam, 1 to 4 percent slopes. Catalpa gravelly clay loam, 0 to 1 percent slopes.
2. Noncalcareous:	
a. Surface soil dark grayish brown; internal drainage medium; frequently to occasionally flooded areas along streams that drain Blackland Prairie.	Kaufman series: Kaufman clay loam, 0 to 1 percent slopes. Kaufman loam, 0 to 1 percent slopes.

DESCRIPTIONS OF THE SOILS

In the following pages the soils are described in detail, and their agricultural relations are discussed. Their location and distribution are shown on the accompanying map; their total acreage and the acreage in various uses are given in table 5.

TABLE 5.—*Approximate acreage in various uses and total acreage of the soils mapped in McLennan County, Tex.*

Soil	Cropland	Pasture	Woodland	Idle	Urban	Total
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Alluvial soils, undifferentiated, 0 to 1 percent slopes	200	1,200	1,300	(1)	0	2,700
Asa silt loam, 0 to 1 percent slopes	3,200	100	(1)	0	500	3,800
Asa silty clay loam, 0 to 1 percent slopes	1,400	(1)	(1)	0	0	1,400
Asa very fine sandy loam, 0 to 1 percent slopes	700	100	0	(1)	0	800
Austin - Eddy gravelly clay loams, 1 to 4 percent slopes	3,500	1,400	300	(1)	100	5,300
Austin silty clay, 1 to 4 percent slopes	20,400	700	100	0	2,700	23,900
Austin silty clay, 4 to 8 percent slopes	8,400	1,800	300	(1)	600	11,100
Austin silty clay, 8 to 15 percent slopes	100	300	0	0	0	400
Austin silty clay, shallow variant, 1 to 4 percent slopes	12,400	900	(1)	(1)	500	13,800
Austin silty clay, shallow variant, 4 to 8 percent slopes	2,100	1,300	100	(1)	200	3,700
Axtell fine sandy loam, 0 to 2 percent slopes	10,100	1,900	2,600	100	400	15,100
Axtell very fine sandy loam, 0 to 1 percent slopes	1,200	500	2,700	(1)	100	4,500
Bastrop fine sandy loam, 0 to 1 percent slopes	3,200	500	(1)	(1)	1,100	4,800
Bastrop fine sandy loam, 4 to 8 percent slopes	700	600	(1)	(1)	100	1,400
Bastrop very fine sandy loam, 0 to 1 percent slopes	2,000	100	(1)	(1)	200	2,300
Bell clay, 0 to 1 percent slopes	16,900	500	(1)	(1)	900	18,500
Bell clay, 1 to 4 percent slopes	4,500	400	(1)	(1)	0	4,900
Bell clay, noncalcareous variant, 0 to 1 percent slopes	1,600	(1)	(1)	0	0	1,600
Brazos loamy very fine sand, 0 to 1 percent slopes	500	200	0	200	0	900
Brazos silt loam, 0 to 1 percent slopes	300	(1)	0	(1)	0	300
Brewer clay loam, 0 to 1 percent slopes	2,000	400	(1)	(1)	200	2,600
Broken land, Catalpa soil material	100	1,100	200	(1)	(1)	1,400
Burleson clay, 0 to 1 percent slopes	4,800	2,600	100	(1)	200	7,700
Burleson clay, 1 to 3 percent slopes	1,200	200	(1)	(1)	0	1,400
Burleson-Houston clays, 1 to 3 percent slopes	19,000	2,400	100	0	200	21,700

See footnote at end of table.

TABLE 5.—*Approximate acreage in various uses and total acreage of the soils mapped in McLennan County, Tex.*—Continued

Soil	Cropland	Pasture	Woodland	Idle	Urban	Total
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Catalpa clay, 0 to 1 percent slopes, frequently flooded	6, 800	3, 800	2, 600	(1)	100	13, 300
Catalpa clay, 0 to 1 percent slopes, occasionally flooded	4, 000	700	900	(1)	0	5, 600
Catalpa clay, 1 to 4 percent slopes	2, 800	400	(1)	(1)	0	3, 200
Catalpa clay loam, 0 to 1 percent slopes, frequently flooded	1, 600	1, 200	300	(1)	0	3, 100
Catalpa clay loam, 0 to 1 percent slopes, occasionally flooded	900	500	200	0	0	1, 600
Catalpa clay loam, 1 to 4 percent slopes	700	200	(1)	0	(1)	900
Catalpa gravelly clay loam, 0 to 1 percent slopes	200	100	(1)	0	0	300
Crawford clay, 1 to 3 percent slopes	8, 900	300	200	0	400	9, 800
Crawford clay, shallow variant, 1 to 3 percent slopes	6, 200	400	100	0	600	7, 300
Crockett clay loam, severely eroded, 3 to 8 percent slopes	1, 100	600	400	100	(1)	2, 200
Crockett loam, 1 to 3 percent slopes	2, 500	300	300	(1)	300	3, 400
Crockett loam, 3 to 8 percent slopes	400	600	200	(1)	(1)	1, 200
Crockett loam, 8 to 15 percent slopes	(1)	200	700	0	(1)	900
Denton clay, 1 to 4 percent slopes	20, 500	2, 500	100	100	5, 600	28, 800
Denton clay, shallow variant, 1 to 4 percent slopes	16, 900	3, 900	100	100	1, 800	22, 800
Eddy gravelly clay loam, 4 to 15 percent slopes	1, 800	3, 500	2, 000	(1)	100	7, 400
Eddy gravelly clay loam, 15 to 50 percent slopes	(1)	500	2, 100	0	100	2, 700
Eddy silty clay, 8 to 15 percent slopes	700	400	100	100	0	1, 300
Ellis clay, 6 to 15 percent slopes	100	200	400	(1)	0	700
Eufaula fine sand, 0 to 2 percent slopes	900	300	400	100	(1)	1, 700
Hortman-Axtell fine sandy loams, 4 to 10 percent slopes	900	900	600	(1)	(1)	2, 400
Hortman fine sandy loam, 2 to 4 percent slopes	500	100	200	0	(1)	800
Houston Black clay, 0 to 1 percent slopes	3, 700	(1)	0	0	(1)	3, 700
Houston Black clay, 1 to 4 percent slopes	73, 300	3, 300	100	100	3, 600	80, 400
Houston Black clay, moderately deep variant, 1 to 4 percent slopes	1, 700	(1)	0	0	100	1, 800
Houston Black gravelly clay, 1 to 4 percent slopes	4, 600	500	100	0	0	5, 200

See footnote at end of table.

TABLE 5.—*Approximate acreage in various uses and total acreage of the soils mapped in McLennan County, Tex.*—Continued

Soil	Cropland	Pasture	Woodland	Idle	Urban	Total
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Houston clay, 1 to 4 percent slopes	11,500	900	(1)	(1)	700	13,100
Houston clay, 4 to 8 percent slopes	20,600	6,400	300	100	500	27,900
Houston clay, 8 to 15 percent slopes	1,600	5,900	400	(1)	100	8,000
Irving-Axtell complex, 0 to 1 percent slopes	3,500	200	500	0	100	4,300
Irving clay loam, 0 to 1 percent slopes	6,600	600	200	(1)	500	7,900
Irving clay loam, 1 to 3 percent slopes	3,000	500	(1)	(1)	(1)	3,500
Irving silt loam, 0 to 1 percent slopes	1,800	200	300	(1)	200	2,500
Ivanhoe-Irving-Axtell complex, 0 to 1 percent slopes	1,100	200	0	0	300	1,600
Kaufman clay loam, 0 to 1 percent slopes	2,100	1,100	800	0	(1)	4,000
Kaufman loam, 0 to 1 percent slopes	200	300	(1)	0	(1)	500
Krum clay, 4 to 8 percent slopes	200	2,000	0	0	0	2,200
Lewisville clay, 0 to 1 percent slopes	1,300	100	(1)	0	0	1,400
Lewisville clay, 1 to 4 percent slopes	8,700	1,200	300	(1)	100	10,300
Lewisville clay, 4 to 8 percent slopes	1,000	700	(1)	(1)	200	1,900
Lewisville clay loam, 1 to 4 percent slopes	1,200	100	(1)	0	(1)	1,300
Lewisville clay loam, 4 to 8 percent slopes	200	100	(1)	0	0	300
Milam fine sandy loam, 1 to 4 percent slopes	1,200	300	500	(1)	(1)	2,000
Milam fine sandy loam, 4 to 8 percent slopes	300	200	100	(1)	0	600
Milam loamy fine sand, 1 to 4 percent slopes	700	300	200	(1)	(1)	1,200
Miller clay, 0 to 1 percent slopes	5,000	400	400	100	(1)	5,900
Norge clay loam, 1 to 4 percent slopes	1,100	100	100	0	(1)	1,300
Norge fine sandy loam, 1 to 4 percent slopes	900	100	(1)	(1)	(1)	1,000
Norwood silt loam, 0 to 1 percent slopes	2,300	100	100	(1)	100	2,600
Norwood silty clay loam, 0 to 1 percent slopes	1,500	300	100	(1)	(1)	1,900
Patrick clay, 1 to 4 percent slopes	1,800	700	200	(1)	(1)	2,700
Patrick gravelly clay, 2 to 15 percent slopes	500	1,200	300	(1)	(1)	2,000
Payne clay loam, 1 to 2 percent slopes	4,700	700	100	(1)	(1)	5,500
Pledger clay, 0 to 1 percent slopes	2,100	200	200	(1)	(1)	2,500

See footnote at end of table.

TABLE 5.—*Approximate acreage in various uses and total acreage of the soils mapped in McLennan County, Tex.*—Continued

Soil	Cropland	Pasture	Woodland	Idle	Urban	Total
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Riesel-Axtell gravelly loams, 4 to 8 percent slopes	200	400	700	[1]	[1]	1,300
Riesel-Axtell gravelly loams, 1 to 4 percent slopes	1,700	600	1,200	[1]	[1]	3,500
Riesel-Irving gravelly clay loams, 1 to 4 percent slopes	1,400	400	200	0	[1]	2,000
Riesel-Irving gravelly clay loams, 4 to 8 percent slopes	300	300	200	[1]	0	800
Riverwash	[1]	0	0	2,200	0	2,200
Rough broken land	200	4,200	2,200	200	[1]	6,800
Rough stony land, Brackett soil material	[1]	1,300	3,900	0	[1]	5,200
San Saba clay, 0 to 2 percent slopes	16,400	1,400	[1]	[1]	4,600	22,400
San Saba clay, shallow variant, 0 to 1 percent slopes	200	100	100	0	0	400
San Saba-Crawford stony clays, 1 to 2 percent slopes	100	1,300	4,200	[1]	[1]	5,600
Sawyer fine sandy loam, 0 to 1 percent slopes	1,500	300	300	[1]	200	2,300
Stidham loamy fine sand, 0 to 2 percent slopes	500	100	100	[1]	[1]	700
Sumter clay, 8 to 20 percent slopes	3,900	2,400	100	100	200	6,700
Tarrant-Brackett stony clays, 8 to 20 percent slopes	300	2,700	500	[1]	0	3,500
Tarrant stony clay, 1 to 8 percent slopes	7,200	24,600	3,000	500	500	35,800
Travis fine sandy loam, 1 to 4 percent slopes	300	100	100	[1]	[1]	500
Travis fine sandy loam, 4 to 8 percent slopes	100	[1]	[1]	[1]	[1]	100
Trinity clay, 0 to 1 percent slopes	14,500	5,100	1,700	100	200	21,600
Vanoss fine sandy loam, 0 to 1 percent slopes	400	[1]	[1]	[1]	400	800
Vanoss silt loam, 0 to 1 percent slopes	2,200	[1]	0	[1]	600	2,800
Wilson clay loam, 0 to 1 percent slopes	1,100	[1]	[1]	0	0	1,100
Wilson clay loam, 1 to 3 percent slopes	23,900	4,400	900	[1]	300	29,500
Wilson-Houston complex, 3 to 8 percent slopes	5,200	4,200	800	[1]	[1]	10,200
Wilson-Houston complex, 8 to 15 percent slopes	200	600	200	0	0	1,000
Yahola silt loam, 0 to 1 percent slopes	1,300	900	300	[1]	[1]	2,500
Yahola very fine sandy loam, 0 to 1 percent slopes	1,000	400	100	[1]	200	1,700
Total	453,000	125,500	46,000	4,200	[2] 30,700	[2] 659,400

[1] Trace.

[2] Does not include miscellaneous urban areas of 1,000 acres (cemeteries, 300 acres; gravel pits, 700) and 6,600 acres of water areas, 400 of which are intermittent lakes.

ALLUVIAL SOILS, UNDIFFERENTIATED, 0 TO 1 PERCENT SLOPES

Alluvial soils, undifferentiated, 0 to 1 percent slopes (Aa) comprise areas of very recent deposits of sands and silts dropped by the Brazos River when at flood stage. All of this land type is located in the Brazos River bottoms near the river channel. The areas are unstable and are modified during periodic floods by addition or removal of soil material. Most of them are loose light-brown calcareous fine sand several feet deep, but there are some low flats where clay loam or clay prevails. The river channel is constantly shifting in the more southerly part of the county, and many places that are now Alluvial soils, undifferentiated, 0 to 1 percent slopes, were in the river channel only a few years ago.

This land type is unfit for crops and is used for pasture. The pasture affords much grazing of nutritious quality. Bermudagrass thrives and has sodded many areas. Scattered cottonwood trees are generally present. These soils are nonarable and are in agronomic group 22.

ASA SERIES

The Asa series is made up of alluvial soils that consist of slightly altered silty stream sediments originating in the Red Plains and prairies of Texas and Oklahoma. They are characterized by dark-brown to brown noncalcareous or slightly calcareous surface soils, dark-brown permeable subsoils of good water-holding capacity, and light-brown or light reddish-brown highly calcareous silty or loamy substrata. In McLennan County the Asa soils occupy high places on the flood plain of the Brazos River, where floods and deposition of fresh sediments are infrequent. Their sole defect is susceptibility to occasional flooding. Associated soils are mainly the Norwood, which consist of relatively unaltered stream sediments without a darkened surface layer, and the Brazos, which have a very sandy subsoil. All of the soils in the Asa series are very largely in cultivation. The three types are about equally productive and are used for the same crops.

Asa silt loam, 0 to 1 percent slopes (Ab).—This is a dark-brown, fertile, easily worked, well-drained soil. It is one of the most productive soils of the county and is well suited for all common field crops and a variety of special crops.

Representative profile (2 miles north of Waco):

0 to 12 inches, dark-brown noncalcareous silt loam; very friable and weakly granular; neutral to alkaline.
12 to 30 inches, brown noncalcareous heavy silt loam; friable and freely permeable.
30 to 70 inches +, light-brown to reddish-brown highly calcareous silt loam; friable and freely permeable.
VARIATIONS: In places the soil material is calcareous to the surface; in many areas the dark-brown color continues to a depth of 18 inches.

Location: The principal areas lie about 5 miles north of Waco.
Relief and Drainage: Nearly level areas of flood plain; both runoff and internal drainage are medium; floods occur at intervals of 5 to 20 years and usually recede within 24 hours.
Erosion: Uneroded and not susceptible to erosion.
Parent Material: Recent sediments of the Brazos River.

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Native Vegetation: Dense forest of oak, ash, pecan, and other hardwoods.
Utilization: Mainly cotton and corn, together with some alfalfa, vegetables for market, and minor areas of sorghums and small grains.
Land Class and *Agronomic Group:* First class; group 1.

Asa silty clay loam, 0 to 1 percent slopes (Ac).—This alluvial soil of the Brazos River bottoms is dark brown, fertile, and easily worked. It occurs in areas ranging up to 300 acres in size. It is one of the most productive soils of the county and is largely in cultivation.

Representative profile:

0 to 15 inches, dark-brown noncalcareous silty clay loam; very crumbly; granular; neutral or mildly alkaline.
15 to 30 inches, dark-brown noncalcareous heavy silty clay loam; permeable; granular.
30 to 100 inches +, brown calcareous silty clay loam; permeable and friable.
VARIATIONS: In places the soil material is calcareous to the surface.

Location: Most areas lie north of Waco.
Relief and Drainage: Level areas of flood plain; runoff is slow, internal drainage is medium.
Erosion: Uneroded and not susceptible to erosion.
Parent Material: Recent sediments of the Brazos River.
Native Vegetation: Hardwood forest.
Utilization: Mainly cotton and corn; small acreages of alfalfa and sorghums.
Land Class and Agronomic group: First class; group 1.

Asa very fine sandy loam, 0 to 1 percent slopes (Ad).—This is a brown, easily worked, well-drained soil. It is very productive and practically all in cultivation.

Representative profile (5 miles north of Waco):

0 to 15 inches, brown to dark-brown slightly calcareous very fine sandy loam; very friable; weakly granular.
15 to 36 inches, brown calcareous silt loam; very friable and permeable; weakly granular.
36 to 60 inches +, light-brown calcareous silt loam; permeable.
VARIATIONS: In many places the soil material is noncalcareous to a depth of 24 inches.

Location: Associated with Asa silt loam and Brazos soils in the higher parts of the Brazos flood plain: largest area is 7 miles northwest of Waco.
Relief and Drainage: Nearly level areas of flood plains; internal drainage is medium; floods at intervals of 10 to 20 years that recede within 24 hours.
Erosion: Uneroded and not susceptible to erosion.
Parent Material: Recent sediments of the Brazos River.
Native Vegetation: Hardwood forest.
Utilization: Mainly in cotton and corn; pasture.
Land Class and Agronomic Group: First class; group 1.

AUSTIN SERIES

The Austin series comprises very granular dark grayish-brown to grayish-brown highly calcareous soils developed on chalk or chalky marl. Typically they have more than 18 inches of soil over parent

material. Shallow variants are 7 to 18 inches deep over chalk, and the gravelly clay loam is 4 to 8 inches deep. The soils occupy moderately to rapidly drained areas of upland in the Blackland Prairie. The relief is gently sloping. The principal associated soils are the Houston Black clays, which occupy more nearly level, more slowly drained situations, and Eddy soils, which are grayer, less dark, and characteristically more sloping and eroded. The highly granular structure of the surface soil and the more permeable subsoils and substrata distinguish the Austin soils from the Houston.

In the more western parts of the Blackland Prairie there are considerable areas of very granular brown to dark-brown calcareous soils with moderate internal drainage. These soils that developed on yellow friable marls are included with the Austin series.

The extensive soils of the Austin series are well suited for use as cropland. They are mostly in cultivation and are used for common field crops; small grains, particularly oats, are extensively grown.

Austin silty clay, 1 to 4 percent slopes (Ar).—This is a moderately dark very crumbly well-drained fertile soil of medium depth. It occupies areas of upland prairie and is a dominant soil in those parts of the Blackland Prairie that are underlain by soft chalk or friable marl. This soil is moderately susceptible to erosion but well suited to cultivation. It is slightly less fertile but better drained and somewhat easier to work than the types of Houston Black clay. Use of practices that increase soil fertility, such as the plowing under of winter legumes to add nitrogen and organic matter, results in marked increases in crop yields.

Representative profile (8 miles southwest of Waco):

0 to 15 inches, dark grayish-brown highly calcareous silty clay; very granular; friable.
15 to 22 inches, grayish-brown highly calcareous silty clay; very granular; friable and moderately permeable.
22 to 30 inches, pale-brown highly calcareous silty clay; friable; permeable.
30 to 50 inches +, substratum of slightly weathered chalky marl or soft chalk.

VARIATIONS: In the areas underlain by chalky marl or chalk, which are typical and most extensive, the surface soil ranges from dark grayish brown to grayish brown and from 10 to 18 inches in depth, the depth depending mainly on the degree of erosion.

In the more western areas of this soil, which have developed in a yellow friable highly calcareous clay (Eagle Ford) that underlies the chalk, the surface soil is yellowish-brown crumbly but sticky clay and the subsoil is light yellowish-brown granular permeable silty clay. This variation comprises all areas mapped as Austin silty clay, 1 to 4 percent slopes, west of the Whiterock escarpment, and all of those in the belt of Eddy soils that passes north-south through the middle of the county. In both areas the depth to relatively unweathered material ranges from 18 to 42 inches.

Location: In the Blackland Prairie mainly south of Waco between the Missouri-Kansas-Texas Railroad and the Brazos River and near Moody; smaller areas near West and Mart.

Relief and Drainage: Gently sloping upland; runoff is medium to rapid, internal drainage is medium.

Erosion: Moderately to slightly susceptible; slight to moderate erosion (the darkened surface layer appreciably thinned, but the inherent productivity decreased less than 20 percent); gullies and rills are absent or few.

Parent Material: Chalky marl and soft chalk (Austin formation) or yellowish friable highly calcareous clay (Eagle Ford formation).
Native Vegetation: Tall prairie grasses.
Utilization: Mainly cotton and corn but considerable acreages of sorghums and oats; more suitable for vegetables and fruit trees than the Houston Black clays.
Land Class and Agronomic Group: First class; group 5.

Austin silty clay, 4 to 8 percent slopes (Ak).—This sloping soil is more susceptible to erosion and less suited to intertilled crops than Austin silty clay, 1 to 4 percent slopes. The surface soil generally is thinner, less dark, and more eroded. Yields vary considerably with management and severity of erosion. When this soil was first placed in cultivation the yields generally were 200 to 300 pounds of lint cotton, 20 to 40 bushels of corn, and 30 to 50 bushels of oats. The original level of productivity probably can be regained with proper management.

Representative profile: Similar to that of Austin silty clay, 1 to 4 percent slopes.

VARIATIONS: Same as in Austin silty clay, 1 to 4 percent slopes. The variation having surface soil of yellowish-brown sticky clay, comprising all areas mapped as Austin silty clay, 4 to 8 percent slopes, in the western half of the county, has a total area of 5,600 acres.

Location: Comprises nearly all the moderately sloping areas associated with Austin silty clay, 1 to 4 percent slopes; the largest areas are along drainageways south of Waco.
Relief and Drainage: Moderately sloping upland, the slopes mostly 300 to 500 feet long and sufficiently uniform that contour cultivation is practicable; runoff is rapid, internal drainage is medium.
Erosion: Very susceptible; in the areas that have been cultivated (about 9,600 acres or 86 percent of the area) erosion has so thinned the darkened surface layer that it now averages about half as thick as in undisturbed prairie. Numerous rills and some deep gullies occur; prevailing yields are much lower than before erosion, but productivity probably could be almost fully restored by good soil management.
Parent Material: Chalky marl and soft chalk (Austin formation) or yellowish friable marly clay (Eagle Ford formation).
Native Vegetation: Medium-height prairie grasses.
Utilization: Cotton, oats, corn, sorghums for grain and forage, and some sudangrass for cultivated pasture.
Land Class and Agronomic Group: Third class; group 11.

Austin silty clay, 8 to 15 percent slopes (Al).—This soil comprises hilly areas occupied by very crumbly brown or grayish-brown silty clay or clay underlain by yellow friable marl. It is distinguished from smoother phases of Austin silty clay by the hilly topography. Its proper use is for permanent grassland.

Representative profile (a native pasture 4 miles northeast of Moody):

0 to 8 inches, brown calcareous silty clay or clay; very granular.
8 to 15 inches, yellowish-brown calareous silty clay or clay; very granular; permeable.

15 to 60 inches +, parent material of pale-yellow, friable, permeable marl, a part of the Eagle Ford formation.
VARIATIONS: Areas with rock-outcrop symbols indicated on map have narrow outcrops of flaggy limestone, fragments of which are scattered over adjacent places.

Location: The areas are few and restricted to one locality 4 miles northeast of Moody and another 2 miles north of Tokio.
Relief and Drainage: Hilly; runoff is very rapid; internal drainage is medium.
Erosion: Too susceptible to erosion to be suitable as cropland.
Parent Material: Yellow friable marl or highly calcareous clay.
Native Vegetation: Medium-height prairie grasses.
Utilization: Mainly pasture, some cropland.
Land Class and Agronomic Group: Nonarable; group 21.

Austin silty clay, shallow variant, 1 to 4 percent slopes (Ac).—This is a very crumbly grayish-brown soil, 7 to 18 inches deep over chalk, that developed in smooth well-drained areas of Blackland Prairie. It is suitable for crops but is only moderately productive. Small grains, however, do well and produce yields almost equal to those obtained on deeper soils. Since the soil is shallow, it cannot store large quantities of soil moisture, and summer crops are therefore more susceptible to drought than on deeper soils.

Representative profile (10 miles southwest of Waco):

0 to 10 inches, dark grayish-brown calcareous silty clay; very crumbly and granular.
10 to 16 inches, grayish-brown highly calcareous silty clay; friable; very granular; permeable.
16 to 40 inches +, parent material of white chalk that is somewhat weathered and contains seams of earth to a depth of about 30 inches.
VARIATIONS: The depth to chalk ranges from 7 to 18 inches but is more than 12 inches in a very large proportion of the area; color of the surface soil ranges from grayish brown to very dark grayish brown.

Location: Principal soil in a belt extending southward from Waco immediately west of the Missouri-Kansas-Texas Railroad; other areas are west of Elm Mott and near West. The principal associated soil on the more nearly level, more slowly drained areas is Houston Black clay, moderately deep variant, 1 to 4 percent slopes; those on more strongly sloping areas are Austin silty clay, shallow variant, 4 to 8 percent slopes, and phases of Eddy gravelly clay loam.
Relief and drainage: Gently sloping upland; both runoff and internal drainage are medium.
Erosion: Moderately to slightly susceptible; 10,200 acres, or 74 percent of the area, has moderate erosion (the surface soil appreciably thinned); 3,600 acres, or 26 percent, has little or no erosion.
Parent Material: Chalk.
Native Vegetation: Medium-height prairie grasses.
Utilization: Mainly oats and wheat; moderate acreages of cotton, grain sorghums, and corn; some pasture.
Land Class and Agronomic Group: Third class; group 12.

Austin silty clay, shallow variant, 4 to 8 percent slopes (Ah).—This soil is similar to Austin silty clay, shallow variant, 1 to 4 percent slopes, except for more sloping relief. Being moderately sloping, it will erode rapidly when cropped unless carefully managed. It is

poorly suited to most crops except small grains.

Representative profile (3½ miles southeast of Moody):

0 to 10 inches, dark grayish-brown or grayish-brown calcareous silty clay; very granular; crumbly.
10 to 15 inches, grayish-brown to pale-brown calcareous silty clay; very granular; friable; permeable.
15 to 30 inches, parent material of partly weathered chalk, with brownish earth in crevices.
30 to 60 inches +, parent rock of solid chalk.
VARIATIONS: The depth to chalk ranges from 7 to 18 inches; the thickness of the darker surface soil layer varies from about 6 to 15 inches.

Location and Extent: Numerous small areas on moderate slopes within those parts of the Blackland Prairie that are underlain by chalk, as near Eddy, Lorena, and Hewitt.

Relief and Drainage: Moderately sloping upland; runoff is rapid, and internal drainage is medium.

Erosion: Very susceptible; areas that have been cropland at one time or another, about 2,700 acres or 73 percent of the total, are much eroded, the dark surface layer averaging about one-half as thick as in areas of native grassland.

Parent Material: Chalk.

Native Vegetation: Medium-height prairie grasses.

Utilization: The principal field crop is oats, but cotton, corn, sorghums, and wheat are grown to a considerable extent; pasture.

Land Class and Agronomic Group: Fourth class, group 16.

Austin-Eddy gravelly clay loams, 1 to 4 percent slopes (AE).—This complex comprises intermingled areas of dark grayish-brown and light brownish-gray gravelly soils very shallow over chalk. These areas are very gentle knolls surrounded for the most part by Austin silty clay, shallow variant, 1 to 4 percent slopes. The depth to chalk ranges from about 4 to 8 inches; the gravel in the soils consists of chalk fragments. The dark grayish-brown to grayish-brown Austin gravelly clay loam is dominant and makes up two-thirds to four-fifths of most areas of the complex. Intermingled with it, however, are small patches of grayer and lighter colored Eddy gravelly clay loam. As a whole, the complex is hardly suited for crops and is used for pasture. Small areas can be included in fields along with deeper soils. Small grains do better than other field crops.

Representative profile of Austin gravelly clay loam (4 miles southwest of Waco):

0 to 4 inches, grayish-brown calcareous silty clay or clay loam containing numerous fragments of chalk; mealy and very granular.
4 to 24 inches, parent material of slightly weathered chalk with some brown soil in crevices.
24 to 40 inches +, parent rock of solid chalk.
VARIATIONS: Cultivated areas appear lighter in color because of the many pieces of white chalk.

Location: Many, mostly small, areas associated with shallow Austin soils west of the Missouri-Kansas-Texas Railroad between Waco and Eddy.

Relief and Drainage: Gently sloping upland; both runoff and internal drainage are medium.

Erosion: Slight to moderate in cultivated areas. No erosion can be tolerated in these soils very shallow over chalk.
Parent Material: Chalk.
Native Vegetation: Prairie grasses, and small live oak trees in some places.
Utilization: The principal crop is oats; cotton and sorghums are the other usual crops; corn is not grown unless absolutely necessary; native pasture.
Land Class and Agronomic Group: Fourth Class; group 16.

AXTELL SERIES

The Axtell series consists of acid light-colored soils. They were developed under oak forest in slowly drained areas on erosional upland consisting of dissected old high stream terraces. The Axtell soils somewhat resemble the Leaf soils of more eastern areas in Texas, but the surface soils are grayer and the subsoils are darker, more compact, and of distinctly claypan character.

Axtell fine sandy loam, 0 to 2 percent slopes (Am).—This soil is a grayish-brown to light brownish-gray soil 6 to 12 inches deep over tough intractable sandy clay. It is the principal soil of the sandy timbered uplands and is commonly known as post oak land (pl. 1, *A*). The soil is acid except in the surface layer. It is low in organic matter, comparatively infertile, and droughty. Low crop yields prevail in most fields, and high yields are seldom or never obtained. Although the fertility can be increased greatly by good soil management, the soil probably cannot be made highly productive because it has a claypan.

Representative profile (a forested area 1 mile south of Harrison):

0 to 5 inches, grayish-brown fine sandy loam; neutral.
5 to 10 inches, light brownish-gray fine sandy loam; strongly acid.
10 to 20 inches, mottled reddish-brown, gray, and yellow compact heavy sandy clay; strongly acid; very slowly permeable.
20 to 35 inches, light yellowish-brown sandy clay mottled with red; compact; moderately acid.
35 to 55 inches, mottled light olive-gray and yellow noncalcareous compact sandy clay.
55 to 70 inches +, mottled light olive-gray and pale-yellow, calcareous, compact sandy clay.

VARIATIONS: The depth of the sandy layers over the claypan subsoil ranges from 4 to 12 inches. In cultivated areas the surface soil is light brownish gray and becomes very hard on drying. In places transitional to prairies the grayish-brown surface layer is thicker and the lighter colored subsurface layer becomes very thin or locally wanting. Some places (shown on the soil map by gravel symbols) have much fine gravel in the surface soil.

Location: Is the most extensive soil of the sandy timbered uplands and old terraces; many large and small areas, concentrated mainly near Ross, Tokio, Elm Mott, and Harrison.
Relief and Drainage: Gently sloping to nearly level high alluvial terraces; runoff is slow to medium, and internal drainage is very slow.
Erosion: Slightly to moderately susceptible; much erosion has occurred on relatively low gradients; slight to moderate erosion prevails in cultivated areas, but local spots, less than 2 acres in size, have lost nearly all of the original sandy surface soil.
Parent Material: More or less calcareous compact sandy clays that are old alluvium.

Native vegetation: Scrub forest of oak with local grassy glades.
Utilization: Principally for cotton, corn, and sorghums; cowpeas, sudangrass, and a few small peach orchards occupy small acreages; pasture.
Land Class and Agronomic Group: Fourth class; group 15.

Axtell very fine sandy loam, 0 to 1 percent slopes (An).—This is a grayish-brown acid soil with a claypan subsoil of mottled reddish-brown, gray, and yellow tough clay. The soil occurs on slowly drained timbered flats. It is droughty, rather difficult to work, and relatively infertile. Some areas are farmed but produce low yields.

Representative profile (a forested area 2 miles southwest of Axtell):

0 to 3 inches, grayish-brown very fine sandy loam; slightly acid; dries to form hard clods.
3 to 6 inches, light-gray very fine sandy loam; moderately acid; rests sharply on underlying subsoil.
6 to 15 inches, mottled reddish-brown, gray, and yellow tough heavy sandy clay; strongly acid; a claypan.
15 to 40 inches, light-olive noncalcareous compact sandy clay containing much very fine sand; not quite so compact as above horizon.
40 to 55 inches, light-olive and yellow noncalcareous compact sandy clay.
55 to 70 inches +, light olive-gray and yellow calcareous compact sandy clay; contains scattered concretions of calcium carbonate.
VARIATIONS: In cultivated areas the entire sandy layer above the heavy clay is light brownish gray; minor variations are in color and degree of mottling of the subsoil; the depth of surface soil over subsoil ranges from 4 to 8 inches.

Location: Near Axtell and along the north side of Trading House Creek.
Relief and Drainage: Nearly level areas on high dissected alluvial plains or terraces; both runoff and internal drainage are very slow.
Erosion: Mostly little or none; moderate erosion on gently sloping margins of areas.
Parent Material: Slightly calcareous sandy clays of alluvial origin.
Native Vegetation: Scrub forest of post oak and blackjack oak.
Utilization: Principally cotton, corn, and sorghums; pasture.
Land Class and Agronomic Group: Fourth class; group 15.

BASTROP SERIES

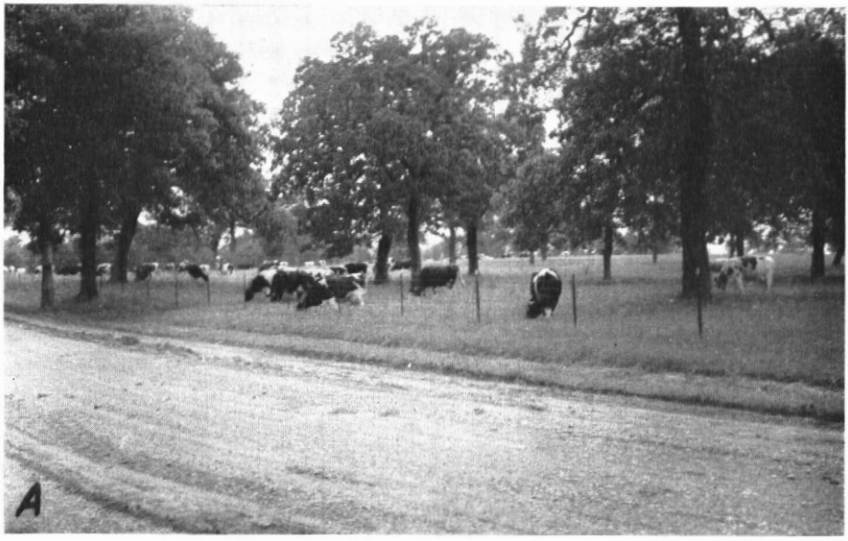
The Bastrop series comprises fertile moderately sandy soils. They occupy well-drained areas on low terraces along the Brazos River. They are underlain by old river sediments of calcareous sands and reddish silts.

The Bastrop soils are fertile, easily worked, and suited to a wide variety of crops. Except for a few sloping areas on terrace escarpments, nearly all of the soils are in cultivation.

Bastrop fine sandy loam, 0 to 1 percent slopes (Ba).—This is a fertile, easily worked, well-drained soil that occurs on low benches adjacent to the Brazos River flood plain. It is particularly favored by farmers for orchard and truck crops but is also well suited to field crops.

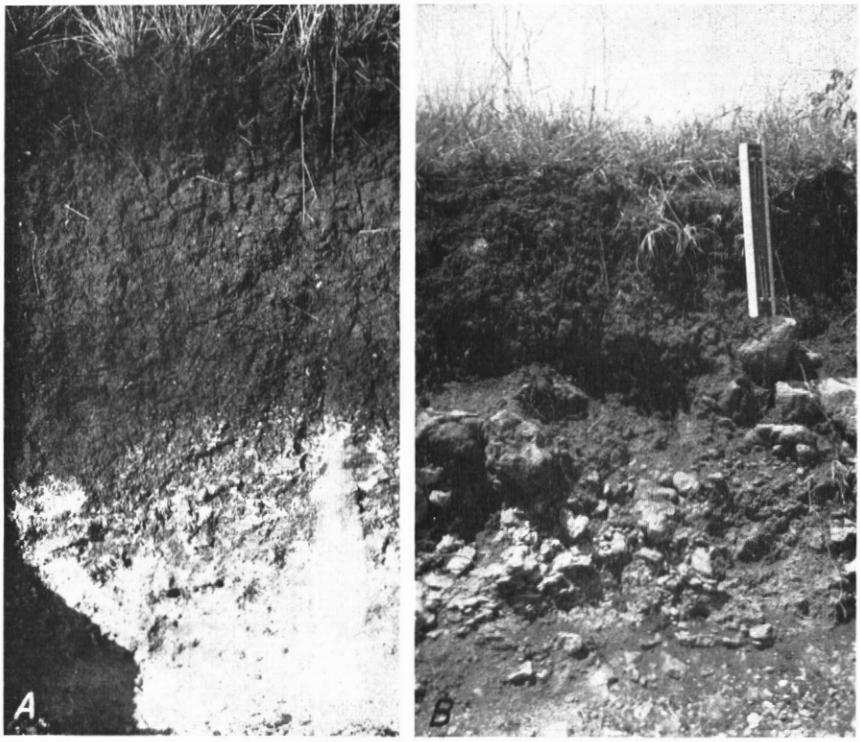
Representative profile (3 miles north of Waco):

0 to 10 inches, grayish-brown mellow fine sandy loam; about neutral.
10 to 13 inches, reddish-brown fine sandy loam; about neutral.



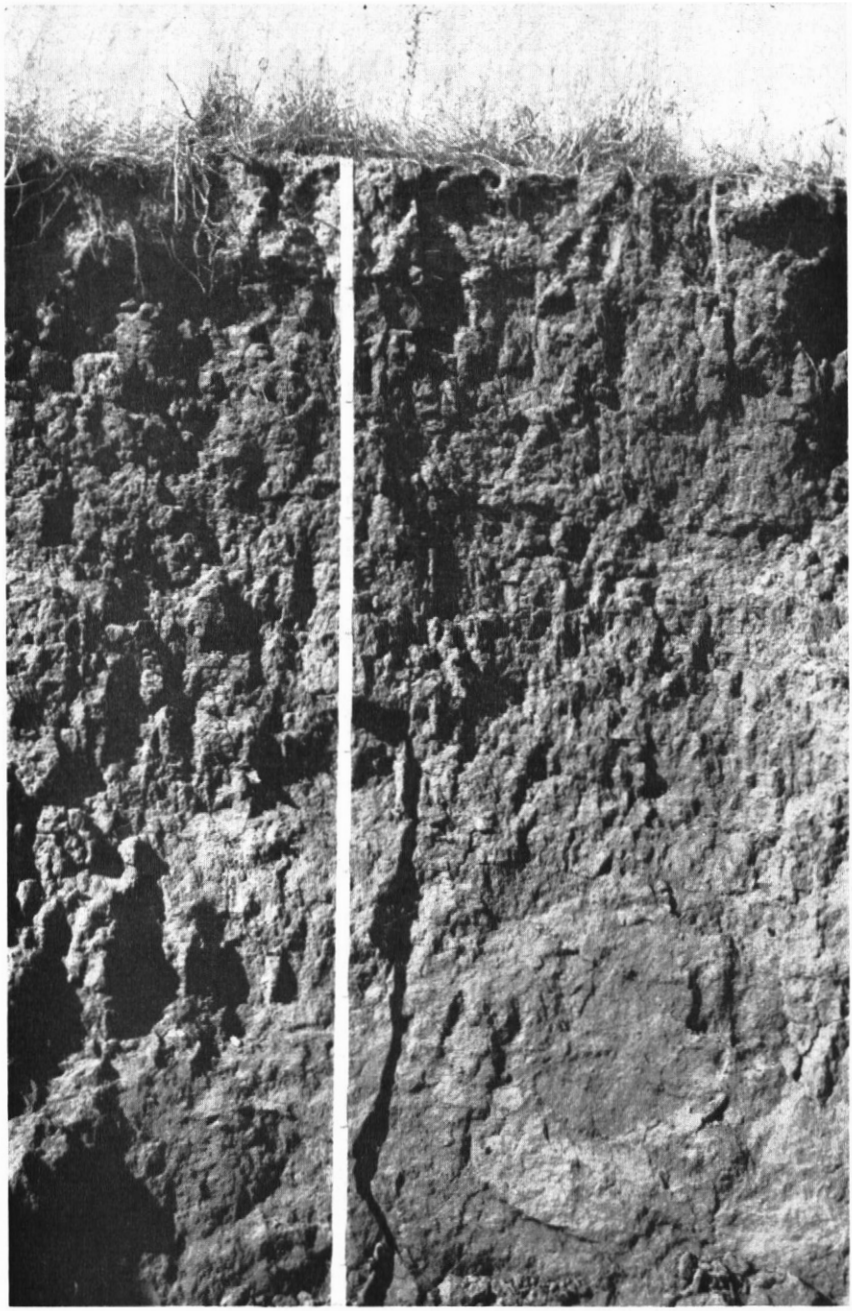
A, Improved dairy pasture on Axtell fine sandy loam, 0 to 2 percent slopes. *B*, Hegari on Crawford clay.

Double-dwarf milo on Denton clay.



A, Profile of Denton clay: 0 to 12 inches, dark-brown granular calcareous clay; 12 to 30 inches, brown calcareous moderately granular clay; 30 to 36 inches, partly weathered limestone; 36 to 48 inches, limestone.

B, Profile of Denton clay, shallow variant. The depth to limestone is about 12 inches.



Profile of Irving clay loam. Note the slightly less dark upper 6 inches, which is the clay loam surface soil; the blocky breakage of the material beneath, which is compact and very slowly permeable; and the depth of dark-colored soil, which continues below the 4½ feet shown in the picture.

13 to 40 inches, yellowish-red to red noncalcareous sandy clay loam; friable and freely permeable; about neutral.
40 to 90 inches, reddish-yellow noncalcareous loam or sandy clay loam.
90 to 120 inches +, reddish-yellow calcareous loam.
VARIATIONS: The depth of the sandy surface layers ranges from 12 to 18 inches.

Location: Adjacent to the Brazos River flood plain; associated with soils of the Vanoss and Brewer series.
Relief and Drainage: Nearly level terraces of the Brazos River; runoff is very slow and internal drainage is medium.
Erosion: Characteristically none or slight, though small areas along the terrace margins have moderate sheet erosion.
Parent Material: Calcareous sandy sediments of the Brazos River.
Native Vegetation: Dense hardwood forest.
Utilization: Cotton, corn, peanuts, vegetables, and fruits; pasture.
Land Class and Agronomic Group: First class; group 6.

Bastrop fine sandy loam, 4 to 8 percent slopes (BB).—Except for steeper slopes and greater susceptibility to erosion when cropped, this soil is similar to Bastrop fine sandy loam, 0 to 1 percent slopes. It comprises sloping areas on the escarpments that lead down from low river terraces to the Brazos River flood plain. It is suitable for crops but requires careful management to prevent erosion if cultivated. As this soil is generally the least suitable cropland on the farms where it occurs, most of it is best used for permanent pasture. This is a Fourth-class soil and is included in agronomic group 19.

Bastrop very fine sandy loam, 0 to 1 percent slopes (Bc).—This soil is very much like Bastrop fine sandy loam, 0 to 1 percent slopes, but differs in the texture of the surface soil. It is fertile, well drained, easily worked, and productive of a wide variety of crops.

Representative profile (3 miles west of Gholson School):

0 to 10 inches, brown mellow very fine sandy loam; about neutral.
10 to 15 inches, reddish-brown friable loam; about neutral.
15 to 36 inches, reddish-brown friable clay loam; about neutral; freely permeable.
36 to 72 inches, yellowish-red noncalcareous friable silt loam.
72 to 120 inches +, reddish-yellow calcareous friable silt loam.
VARIATIONS: None significant.

Location: On low river terraces adjacent to the Brazos flood plain.
Relief and Drainage: Nearly level; runoff is very slow and internal drainage is medium.
Erosion: Only slightly susceptible; 2,000 acres, or 87 percent, has no appreciable erosion; the remaining 300 acres, or 13 percent, is moderately eroded, but productivity has not been lowered more than about 20 percent.
Parent Material: Old sediments of calcareous silts from the Brazos River.
Native Vegetation: Probably forest, possibly partly prairie.
Utilization: Mainly cotton, corn, sorghums, and vegetables.
Land Class and Agronomic Group: First class; group 6.

BELL SERIES

The Bell series comprises black to dark-gray crumbly clays that occur on upland flats or old stream terraces. In the characteristic

types, the soil material is calcareous to the surface. The normal relief is nearly level. The Bell soils are underlain by old alluvium of highly calcareous clay that contains seams of gravel in some places. The soils are deep, fertile, largely in cultivation, and highly regarded by farmers.

Bell clay, 0 to 1 percent slopes (Be).—Bell clay is deep crumbly blackland on stream terraces. In many characteristics it is like the types of Houston Black clay, but it is darker to greater depth and is of different origin.

Representative profile (11 miles south of Waco):

0 to 18 inches, black or dark-gray, calcareous, heavy but crumbly clay; very sticky when wet; granular; indistinct boundary with the underlying layer.
18 to 55 inches, very dark-gray calcareous heavy clay, somewhat more compact and less crumbly than surface layer.
55 to 70 inches, dark-gray calcareous plastic clay with scattered concretions of calcium carbonate.
70 to 95 inches, gray and light-yellow calcareous heavy clay with scattered concretions of calcium carbonate.
95 to 120 inches +, light-gray and pale-yellow calcareous clay.

Location: Broad areas on terraces along nearly all the larger streams; large areas near Speegleville and on the west side of the Brazos River southwards from Waco.
Relief and Drainage: Level; both runoff and internal drainage are very slow.
Erosion: Not susceptible.
Parent Material: Alluvial sediments of calcareous clays.
Native Vegetation: Mostly grass; scattered elm and other trees in places.
Utilization: Cultivated land is used mainly for cotton farming; cotton, corn, and sorghums are the common field crops; some pasture.
Land Class and Agronomic Group: First class; group 4.

Bell clay, 1 to 4 percent slopes (Bd).—This soil is on gently sloping areas and has essentially the same profile as Bell clay, 0 to 1 percent slopes.

Representative profile (11 miles south of Waco):

0 to 18 inches, black calcareous heavy clay; very plastic and sticky when wet; crumbly and granular.
18 to 33 inches, very dark-gray calcareous heavy clay; somewhat more compact and less crumbly than above layer.
33 to 48 inches, dark-gray calcareous heavy clay; contains a few concretions of calcium carbonate.
48 to 80 inches, light-yellow and gray calcareous slowly permeable clay.
80 to 150 inches +, yellow and light-gray moderately permeable calcareous clay.
VARIATIONS: In local areas the surface soil is very dark brown.

Location: Associated with other Bell clays; larger areas are distant from outcrops of chalk or limestone.
Relief and Drainage: Gently sloping margins of alluvial terraces; runoff is medium, and internal drainage is very slow.
Erosion: Slightly to moderately susceptible; cultivated areas show slight to moderate erosion; potential productivity reduced no more than 20 percent.

Parent Material: Alluvial sediments of calcareous clays.
Native Vegetation: Mostly grasses; scattered trees in local areas.
Utilization: Mainly cotton farming; cotton, corn, and sorghums are the principal crops; some pasture.
Land Class and Agronomic Group: First class; group 3.

Bell clay, noncalcareous variant, 0 to 1 percent slopes (Bf).—This soil is like Bell clay, 0 to 1 percent slopes, except that the upper soil layers are noncalcareous. The workability, fertility, relief, drainage, crop yields, and suitability for use are the same for the two soils. All of this noncalcareous variant is in cultivation. The soil material is about neutral in reaction to depths of 20 to 35 inches; below this it is highly calcareous. The largest area lies just north of Leroy; other areas occur 3 to 6 miles north of Waco. This First-class soil is in agronomic group 4.

BRACKETT SERIES

The Brackett series comprises light brownish-gray very shallow soils (Lithosols) on limestone or interbedded limestone and chalky marl in the Grand Prairie. Brackett soils are unsuitable for crops and very poor for pasture because they have a very thin soil layer and numerous outcrops and ledges of limestone and marl. The vegetation is a sparse to moderate cover of small trees and shrubs and some grasses. The Brackett soils are closely associated with the Tarrant, which are darker and much better grassland, and with the Denton, Crawford, and San Saba, which are deeper and darker and are arable. The Brackett series, not extensive in this county, is represented by two units: Rough stony land, Brackett soil material; and, as part of a complex, Tarrant-Brackett stony clays, 8 to 20 percent slopes. Both of these units are described elsewhere in this report.

BRAZOS SERIES

The Brazos series consists of brown to light reddish-brown sandy alluvial soils along the Brazos River. Brazos soils occur on high bottoms that are seldom if ever flooded and are distinguished from the associated Asa soils by their very sandy subsoil. They differ from the closely related Yahola soils of the more frequently flooded lower bottoms in having somewhat darkened, usually noncalcareous, surface layers and somewhat coarser subsoils.

Brazos loamy very fine sand, 0 to 1 percent slopes (Bg).—This sandy soil occupies high areas along the Brazos River flood plain. Representative profile (7 miles north of Waco):

0 to 15 inches, brown or light reddish-brown loamy very fine sand; neutral to calcareous.
15 to 50 inches +, light-brown or light reddish-brown calcareous loamy very fine sand or light very fine sandy loam; stratified with thin seams of fine sand.
VARIATIONS: The areas mapped include a few low ridges on which the surface soil is fine sand or fine sandy loam.

Location: Higher parts of the Brazos River flood plain 7 miles north of Waco and 4 miles southeast of Waco.
Relief and Drainage: Undulating; runoff is slow to medium, internal drainage is rapid.

Erosion: Not susceptible to water erosion; slight wind erosion in places.
Parent Material: Relatively recent sandy sediments of the Brazos River.
Native Vegetation: Forest.
Utilization: Principally corn and cotton; pasture.
Land Class and Agronomic Group: Fourth class; group 18.

Brazos silt loam, 0 to 1 percent slopes (BH).—This is a brown soil with a very sandy subsoil. It occupies higher areas in the Brazos River bottoms. The soil is moderately fertile and easily worked, but the sandy subsoil lowers the water-holding capacity and limits yields of crops.

Representative profile (7 miles north of Waco):

0 to 12 inches, brown to reddish-brown noncalcareous silt loam; very friable and weakly granular.
12 to 20 inches, reddish-brown calcareous silt loam; very friable and permeable.
20 to 50 inches +, light reddish-brown calcareous loamy very fine sand stratified with fine sandy loam.
VARIATIONS: Depth to very sandy material ranges from 10 to 30 inches.

Location and Extent: A few areas 7 miles north and 4 miles southeast of Waco.
Relief and Drainage: Undulating high flood plain; surface drainage is slow to medium; internal drainage is rapid.
Erosion: Not susceptible.
Parent Material: Recent sediments of the Brazos River.
Native Vegetation: Forest.
Utilization: Mainly corn and cotton.
Land Class and Agronomic Group: Second class; group 10.

BREWER SERIES

In McLennan County this series is represented by only one type, Brewer clay loam, 0 to 1 percent slopes, which is associated with Vanoss and Bastrop soils. It has developed in slowly drained areas on terraces of rivers that drain the prairies and plains of Oklahoma and Texas. The Brewer soil differs from the Irving soils in being granular, crumbly, slightly brownish, and in having developed on sediments that are partly from the Red Plains.

Brewer clay loam, 0 to 1 percent slopes (BK).—This is a dark grayish-brown to very dark-gray crumbly noncalcareous clay loam. The soil is fertile, readily worked, and productive for a wide variety of crops.

Representative profile (3 miles north of Waco):

0 to 8 inches, dark grayish-brown noncalcareous friable clay loam; granular; neutral.
8 to 45 inches, very dark-gray to black noncalcareous crumbly clay.
45 to 60 inches, dark grayish-brown calcareous clay.
60 to 85 inches, light brownish-gray calcareous clay, mottled with brownish yellow and containing some sand.
85 to 110 inches +, stratified reddish-brown and yellow calcareous silty clay and sand.
VARIATIONS: In poorly drained places the surface soil is dark gray.

Location and Extent: Occurs on low terraces of the Brazos River; the principal areas are 3 miles north of Waco and 3 miles east of Waco.

Relief and Drainage: Mainly level; a few areas with gradients of more than 1 percent; runoff very slow to none; internal drainage is slow.
Erosion: Not susceptible.
Parent Material: Calcareous clayey alluvium of the Brazos River.
Native Vegetation: Mostly grass; some scattered mesquite trees.
Utilization: Principally cotton, corn, and sorghums; some pasture.
Land Class and Agronomic Group: First class; group 5.

BROKEN LAND, CATALPA SOIL MATERIAL

Broken land, Catalpa soil material (Bl) consists of broken areas in first bottoms. It occupies the streambanks and side gullies. Most of the areas are along the several forks and tributaries of the Bosque River. These areas are from 100 to 300 feet wide. The soil material is recent alluvium and in most places is grayish-brown calcareous soil material similar to that which comprises the Catalpa soils. Uncleared areas support a dense vegetation of trees and grass.

This land type is valuable for pasture, pecan groves, and farm woodlots, but it is very poorly suited to crops. Most of it is used for pasture; some is in woodland; and a small percentage is cultivated. It is classed as nonarable and is in agronomic group 22.

BURLESON SERIES

This series consists of deep, dark-gray to gray, noncalcareous, poorly granulated and crusty, very slowly permeable clayey soils. It occupies level to gently sloping areas on undissected stream terraces and on erosional upland. The parent materials are marine and alluvial montmorillonitic clays that generally contain somewhat less calcium carbonate and more silt and sand than the parent materials of the more granular and naturally crumbly Bell and Houston Black series. Burleson, a new series established to include the soils formerly classed as Irving clay and Wilson clay, differs from the Irving and Wilson series as they are now defined. It differs in having a profile uniformly clayey in all horizons, including the surface soil. During rains the immediate surface of the Burleson soils, which are sometimes called rawhide land, slakes and seals over and permits very slow infiltration. When the soil dries without tillage, a hard crust that prevents emergence of seedlings is formed. Though more intractable and somewhat more droughty than the Houston Black clays, the Burleson soils are moderately productive and clearly suited to crops.

Burleson clay, 0 to 1 percent slopes (Ic).—This is a dark-gray noncalcareous crusty clay that occurs in level areas. The subsoil is a dark-gray compact clay. The soil is well suited as cropland and is moderately productive, but somewhat difficult to work because of its very slow surface drainage and the crustiness of the surface soil, which interferes with emergence of seedlings.

Representative profile:

0 to 40 inches, dark-gray noncalcareous clay; neutral; moderately crumbly to 15 inches, tough and compact below.
40 to 75 inches, dark-gray calcareous tough clay; very slowly permeable.
75 to 85 inches +, light olive-gray calcareous tough clay; very slowly permeable.

VARIATIONS: Surface soil ranges from dark gray to very dark gray.

Location and Extent: Comprises upland areas mostly on high stream terraces along Tehuacana Creek and other drainageways in the eastern part of the county.
Relief and Drainage: Level; runoff is very slow or lacking; internal drainage is very slow.
Erosion: Not susceptible.
Parent Material: Calcareous clays of alluvial origin.
Native Vegetation: Mainly grass.
Utilization: Principally cotton, corn, grain sorghums, and pasture.
Land Class and Agronomic Group: Second class; group 8.

Burleson clay, 1 to 3 percent slopes (Ib).—This soil differs from Burleson clay, 0 to 1 percent slopes, in occupying gently sloping areas where runoff is medium and some erosion occurs under improper farming. It occurs on the margins of high stream terraces occupied mainly by Burleson clay, 0 to 1 percent slopes. It has essentially the same productivity, crop adaptations, and utilization as the associated soil. Approximately 1,200 acres, or 86 percent, is in cultivation, and 200 acres, or 14 percent, is in pasture. A typical body is just south of Leroy. This Second-class soil is in agronomic group 7.

Burleson-Houston clays, 1 to 3 percent slopes (Wd).—This gently sloping complex is a mixture of unequal proportions of two different soils: Burleson clay, and Houston clay. The pattern of distribution is related to the "hog-wallow" relief of the prairie before plowing; the Burleson clay occupies the places that were depressions; the Houston, those that were microridges. Most of the individual soil areas are less than 30 feet wide. The surface soils of the two have been mixed by tillage operations, and the variation in soil character is less conspicuous in cultivated fields than in virgin areas. So far as observed or reported by farmers, crop growth is about the same on the two intermingled soils, except that cotton root rot is much more severe on the Houston.

This complex, generally called blackland, produces good crops of cotton and corn and is farmed in the same manner as the Houston Black clays. It is regarded by farmers as very good land, slightly inferior to the Houston Black clays.

Representative profiles:

Burleson clay, 1 to 3 percent slopes:
Same as for profile of Burlson clay, 0 to 1 percent slopes, as described under that soil type in this report.

Houston clay, 1 to 3 percent slopes:
See profile described for Houston clay, 1 to 4 percent slopes, in this report.

VARIATIONS: The proportions of Burleson clay, 1 to 3 percent slopes, and Houston clay, 1 to 3 percent slopes, vary from about 80 percent and 20 percent, respectively, in the more nearly level areas to about half and half in the more sloping areas. In most cultivated areas admixture by tillage operations has made the plow layer everywhere calcareous.

Location: Broad areas of upland, mainly in the eastern part of the county; transitional between sections largely of Houston Black clays and other sections largely of Wilson clay loams. Associated level areas are Burleson clay, 0 to 1 percent slopes; associated more sloping areas are of Houston clay, 4 to 8 percent slopes.

Relief and Drainage: Very gently sloping upland; convex surfaces; runoff is slow to medium and internal drainage is very slow.
Erosion: Slightly to moderately susceptible; erosion that has occurred is mostly slight, but is moderate in about one-fourth of the area; erosion is nowhere severe.
Parent Material: Calcareous compact clays of marine origin.
Native Vegetation: Tall grasses.
Utilization: Cultivated land used largely for cotton farming; crops grown, in the order of their acreage, are cotton, corn, sorghums, and oats; pasture.
Land Class and Agronomic Group: First-class; group 3.

CATALPA SERIES

The Catalpa series consists of grayish-brown to dark grayish-brown calcareous alluvial soils made up of little-altered recent stream sediments (pl. 5). They are soils of the present flood plains in western and central parts of the county where the sediments are from areas underlain by limestone or chalk. They differ from the Trinity soil, the other principal series of alluvial soils washed from the grasslands, in being less dark and in having freer internal drainage. The Catalpa soils are very productive. Except for small areas that are flooded frequently, they are very largely in cultivation and are highly valued as cropland.

Catalpa clay, 0 to 1 percent slopes, occasionally flooded (CA).—This soil is a limy and crumbly clay several feet deep. It occurs on high bottoms along the North Bosque and other streams that drain the Grand Prairie and is the most extensive member of the series in McLennan County. On these high bottoms floods are infrequent and recede quickly.

Representative profile (2 miles north of Waco):

0 to 30 inches, dark grayish-brown highly calcareous silty clay or clay; granular and crumbly.
30 to 60 inches +, grayish-brown highly calcareous silty clay or light clay; moderately permeable and friable.

Location: High bottoms mostly along the North Bosque River and its tributaries.
Relief and Drainage: Level to gently undulating; runoff is slow and internal drainage is medium; overall drainage is good; on the average, floods occur about once in 2 years.
Erosion: Not susceptible to erosion.
Parent Material: Recent stream sediments along the Grand Prairie.
Native Vegetation: Hardwood forest including much pecan.
Utilization: Cultivated areas used principally for cotton, corn, alfalfa, and sorghums; pasture.
Land Class and Agronomic Group: First-class; group 2.

Catalpa clay, 1 to 4 percent slopes (CB).—This soil is a dark grayish-brown calcareous crumbly clay several feet deep. It consists of foot slopes or alluvial fans along the edges of the flood plains of most streams in the eastern part of the county. The soil areas lie above the usual overflow limit of the nearby major stream, but hillside waters from adjoining slopes flow over them. The soil material was washed from higher areas of Houston clays and associated soils.

The areas are gently sloping. Gradients are mostly 1 to 2 percent, but reach 4 percent next to the valley slopes. Most tracts are too narrow to make up entire fields and lie between areas of Trinity clay and Houston clay.

This soil is well suited as cropland and commonly is the most productive land on the farm where it occurs. Approximately 2,800 acres, or 87 percent, is cultivated. The remaining 400 acres, or 13 percent, is pasture of high carrying capacity. Cotton, corn, and sorghums are the principal crops. A small acreage of alfalfa is grown and produces well. This is a First-class soil and is in agronomic group 2.

Catalpa clay, 0 to 1 percent slopes, frequently flooded (Cc).—This fine-textured soil is on bottom lands along streams other than the Brazos River. The soil is a limy, crumbly, dark grayish-brown clay several feet deep. It is high in fertility, but crop production is somewhat difficult or hazardous because of the frequent floods. Many areas are successfully used as cropland; other large areas are in highly productive pasture.

Representative profile:

0 to 30 inches, dark grayish-brown highly calcareous silty clay or clay; granular and very crumbly.
30 to 60 inches +, dark grayish-brown highly calcareous silty clay or clay; slightly less dark than layer above; moderately permeable.
VARIATIONS: The areas on the flood plain of Aquilla Creek and most other areas east of the Brazos River are of olive-brown heavy clay and have very slow internal drainage.

Location: Flood plains of small and large streams, mostly in the more western parts of the county.
Relief and Drainage: Level or nearly level; runoff is slow; internal drainage is medium in most places but very slow in the areas along Aquilla Creek and along other streams east of the Brazos River; several floods occur nearly every year.
Erosion: Not susceptible.
Parent Material: Stream sediments washed from fine-textured soils of the prairies.
Native Vegetation: Hardwood forest, including many pecan trees.
Utilization: Cotton and corn; pasture.
Land Class and Agronomic Group: Third-class; group 14.

Catalpa clay loam, 0 to 1 percent slopes, occasionally flooded (Cd).—This soil covers areas of calcareous moderately heavy bottom land. It occurs along streams in the Grand Prairie. The principal areas are in the flood plain of the North Bosque River in the northwestern part of the county. The soil is dark grayish-brown calcareous granular clay loam to a depth of about 30 inches. Below this is similar material of slightly lighter color. This soil is fertile, easily worked, adequately drained, and well suited as cropland.

Practically all areas are suitable for cultivation, but only about 900 acres, or 56 percent, is in cultivation. Cotton, corn, and sorghums are the principal crops but some alfalfa is also grown. This is a First-class soil and is in agronomic group 1.

Catalpa clay loam, 1 to 4 percent slopes (Ce).—This is a dark grayish-brown calcareous clay loam several feet deep. It occurs in the eastern parts of the county where the uplands are mostly clay loams

or sandy loams. It consists of local alluvium washed from adjoining slopes and dropped along the borders of flood plains as coalescing alluvial fans. The areas are gently sloping; prevailing gradients are 1 or 2 percent, but approach 4 percent along the upper sides. The soil lies mainly above the usual limit of floodwaters from nearby streams, but receives hillside waters from adjoining slopes. Some of the larger areas are along Aquilla Creek and 3 miles west of Riesel. Most tracts are too narrow to make up entire fields and are farmed along with adjoining first-bottom areas.

This soil is well suited as cropland, but many small areas remain in native grass and timber because of their inaccessability or small size. About 78 percent is in cultivation, and the rest is in pasture. The crops grown are cotton, corn, and sorghums. Yields are about the same as on Catalpa clay loam, 0 to 1 percent slopes, occasionally flooded. This is a First-class soil and is in agronomic group 1.

Catalpa clay loam, 0 to 1 percent slopes, frequently flooded (Cf).—This soil occurs in nearly level areas of moderately heavy bottom land. The largest areas are in the eastern part of the county on the flood plains of streams such as Little Tehuacana and Sandy Creeks, which drain mixed areas of tight and crumbly soils of the Blackland Prairie. Small areas occur along some of the streams in the Grand Prairie. The soil is a highly calcareous dark grayish-brown clay loam several feet deep. It is very fertile, but cropping is difficult or somewhat hazardous because of the frequent floods. Runoff is slow, and internal drainage is medium.

More than half the acreage is cultivated and most of the rest is in pasture. The cultivated land is used for growing cotton, corn, and sorghums. Yields vary widely with the season; they range from failure when floods are unusually destructive to very high when the season favors cultivation. Improved pastures on this soil have a year-round carrying capacity of about 2 acres to the cow. This is a Third-class soil and is in agronomic group 14.

Catalpa gravelly clay loam, 0 to 1 percent slopes (Cg).—This alluvial soil consists of dark grayish-brown calcareous gravelly clay loam to a depth of several feet. It occurs in small areas of first bottoms within the Grand Prairie, mainly next to the stream channels. Typical areas are along the South Bosque River near the Santa Fe railroad. The gravel, which consists of waterworn fragments of limestone ranging up to 4 inches in diameter, makes tillage very difficult, but considerable areas are cultivated.

The cultivated areas are parts of fields that consist largely of better soils. Yields range from very low in places where beds of gravel underlie the soil at shallow depth to very high where the soil is deep. As a whole, the soil is not suited as cropland but will produce excellent pasture. This is classed as a nonarable soil and is in agronomic group 22.

CRAWFORD SERIES

The Crawford series is made up of dark-brown to reddish-brown noncalcareous clays that developed in areas within the Grand Prairie on limestone. These clays resemble the Denton soils in some respects but are finer textured, less crumbly, noncalcareous, somewhat less gray-

ish, and usually more reddish in the subsoil. The crop adaptations, management requirements, and fertility are about the same as for the Denton soils of like depth.

Crawford clay, 1 to 3 percent slopes (CH).—This is a dark-brown to reddish-brown, moderately deep, heavy clay. It resembles Denton clay but is somewhat less crumbly and more reddish and contains no free lime in the upper soil layers. It is very largely in cultivation and is well esteemed by farmers (pl. 1, *B*).

Representative profile (2 miles west of McGregor):

0 to 22 inches, dark-brown noncalcareous heavy clay; neutral; moderately crumbly and granular.
22 to 34 inches, brown calcareous heavy clay; moderately compact and of cloddy breakage; very sticky and plastic when wet.
34 inches +, hard limestone.
VARIATIONS: The color of surface soil ranges from dark reddish brown to dark brown, and that of the subsoil below plow depth, from brown to reddish brown or, in places, red; the depth to limestone varies from 18 to about 40 inches.

Location: Large and small areas in the Grand Prairie; large areas are near McGregor.
Relief and Drainage: Very gently sloping upland; gradients mostly less than 2 percent; both runoff and internal drainage are medium.
Erosion: Slightly susceptible; slight erosion prevails in most cultivated areas; no severely eroded areas.
Parent Material: Hard limestone.
Native Vegetation: Prairie grasses.
Utilization: Principally cotton, corn, oats, and sorghums; some pasture.
Land Class and Agronomic Group: First-class; group 5.

Crawford clay, shallow variant, 1 to 3 percent slopes (CK).—This soil differs from Crawford clay, 1 to 3 percent slopes, in being less than 18 inches deep over limestone. It is moderately shallow. Its productivity of cotton and other summer crops is rather low but it is well suited to small grains.

Representative profile (3 miles east of McGregor):

0 to 14 inches, dark-brown noncalcareous heavy clay; neutral; only moderately crumbly and granular.
14 inches +, hard limestone.
VARIATIONS: Depth of soil over limestone varies between about 10 and 18 inches; color of soil ranges from dark brown to reddish brown; in some places a few loose fragments of limestone occur on the surface.

Location and Extent: Associated with Crawford clay, 1 to 3 percent slopes, and Denton soils in the Grand Prairie; principal areas in the general vicinity of McGregor.
Relief and Drainage: Very gently sloping; both runoff and internal drainage are medium.
Erosion: Mostly slight; some moderate.
Parent Material: Hard limestone.
Native Vegetation: Prairie grasses.
Utilization: Oats, cotton, grain sorghums, corn, and wheat are the principal crops, in descending order of acreage; pasture.
Land Class and Agronomic Group: Third-class; group 12.

CROCKETT SERIES

The Crockett series consists of grayish-brown noncalcareous soils with mottled reddish-brown and gray compact clay subsoils. The soils developed on slightly calcareous compact sandy clay parent materials on undulating to sloping uplands in association with soils of the Wilson and Riesel series. Crockett soils differ from the closely related Riesel soils in being less gravelly and generally somewhat deeper, and from the Wilson in being lighter colored and in having mottled subsoils. Crockett soils are of only moderate productivity and are crusty and somewhat droughty. Where not too sloping, however, they are fairly well suited to some early maturing field crops and to permanent pasture.

Crockett loam, 1 to 3 percent slopes (CM).—This grayish-brown loam is the lightest colored of the tight soils developed under grass in McLennan County. Although somewhat difficult to work, the soil is suited to crops and is largely in cultivation. It is only moderately productive.

Representative profile:

0 to 6 inches, grayish-brown noncalcareous loam; very slightly acid; unless cultivated, becomes very hard on drying.
6 to 15 inches, mottled reddish-brown, gray, and olive-yellow noncalcareous heavy clay; very compact; very slightly acid.
15 to 35 inches, light olive-gray noncalcareous clay slightly mottled with olive yellow; very compact and slowly permeable.
35 to 50 inches +, light-gray slightly calcareous compact sandy clay with scattered concretions of calcium carbonate.
VARIATIONS: In small included areas the surface soil is silt loam.

Location: Scattered areas next to high stream terraces in eastern parts of the county where timbered sandy uplands grade to prairies; some of the larger areas are near Elm Mott and Riesel.
Relief and Drainage: Very gently sloping upland; runoff is medium; internal drainage is very slow.
Erosion: Slightly to moderately susceptible; 62 percent has slight erosion, 38 percent has moderate erosion (the surface soil appreciably thinned and productivity reduced about 25 percent).
Parent Material: Calcareous heavy sandy clays or slightly sandy marl.
Native Vegetation: Prairie grasses.
Utilization: Principal field crops are cotton, corn, and sorghums; pasture.
Land Use and Agronomic Group: Second-class; group 7.

Crockett loam, 3 to 8 percent slopes (CN).—This soil is similar to Crockett loam, 1 to 3 percent slopes, but it is on more sloping areas where erosion is rapid under crops unless the soil is carefully managed. In areas that have been cropped, the surface soil is commonly about 4 inches deep; in native pastures it is from 4 to 7 inches deep. The soil is associated with other Crockett soils and is confined to eastern parts of the county.

This soil has only moderate fertility, difficult tilth, much susceptibility to erosion, and a heavy intractable subsoil. It is therefore better for permanent pasture than for crops.

Many formerly cultivated areas have been retired to pastures consisting mainly of weeds and grasses of low palatability and feeding value. The native prairie pastures have a moderate sod of grass and

where properly grazed have a carrying capacity of about 12 acres to the cow. This is a Fourth-class soil in agronomic group 20.

Crockett loam, 8 to 15 percent slopes (Co).—This hilly soil has a profile like that of Crockett loam, 3 to 8 percent slopes, but all layers are somewhat thinner. The areas are so sloping that they are very poorly suited to crops and are best used for permanent pasture, although some are cultivated. They are on narrow slopes in association with other Crockett loams. Slopes range between 6 and 20 percent but are mostly between 8 and 15. The native vegetation is a mixture of prairie grasses and scattered post oaks. Wherever growth is not inhibited by competition with trees, weeds, or brush, native grasses thrive and produce nutritious, moderately abundant grazing. This is a nonarable soil and is in agronomic group 21.

Crockett clay loam, severely eroded, 3 to 8 percent slopes (Cl.).—This soil is on eroded sloping areas where less than about 3 inches of the original surface soil remains. The heavy subsoil lies within plow depth, and tillage has brought up enough clay to give a clay loam texture to the plowed layer. All areas are severely eroded, infertile, and very poorly suited to crops. Many are abandoned fields, either idle or in pasture, that have a thin growth of weeds and some grass.

This soil occurs in scattered areas in eastern parts of the county, such as the localities of Elm Mott, Riesel, and Axtell. About half of the soil is in cultivation. Most of the rest is in pasture, part of which has a fairly thick scrubby post-oak cover. Much of the cultivated land is cropped only occasionally and is idle about 2 years out of 3. This soil never was well suited to crops, and improper use destroyed much of its utility for pasture. The grazing in pastures is sparse and of poor quality but it can be improved if better grasses are established and weeds are controlled. Bermudagrass and burclover gradually become established under proper management. This is classed as a nonarable soil and is in agronomic group 21.

DENTON SERIES

The Denton series consists of dark-brown to dark grayish-brown, mostly calcareous, very crumbly soils underlain at various depths by limestone (pl. 3, *A*). They are the most extensive soils of the Grand Prairie and occupy well-drained upland. The soils are typically from 18 to about 40 inches deep over limestone. One member of the series, less than 18 inches deep over limestone, is designated as a shallow variant.

Denton clay, 1 to 4 percent slopes (Da).—This is a dark grayish-brown or dark-brown calcareous crumbly clay underlain by limestone. It is one of the deeper and better soils of the Grand Prairie (pl. 2).

Representative profile (1 mile southeast of McGregor):

0 to 18 inches, dark grayish-brown calcareous clay; granular and crumbly.
18 to 30 inches, brown calcareous crumbly clay.
30 to 50 inches +, limestone.
VARIATIONS: The depth to limestone ranges from about 18 to 40 inches; the color of surface soil ranges from dark grayish brown to brown.

Location: The most extensive soil in the nonstony sections of the Grand Prairie in McLennan County.

Relief and Drainage: Gently sloping upland; both runoff and internal drainage are medium.
Erosion: Slightly to moderately susceptible; 76 percent has no or slight erosion, and 24 percent has moderate erosion.
Parent Materials: Limestone interbedded in places with marl.
Native Vegetation: Tall prairie grasses.
Utilization: Cotton, corn, grain sorghums, and wheat; pasture.
Land Class and Agronomic Group: First-class; group 5.

Denton clay, shallow variant, 1 to 4 percent slopes (DB).—This is a brown or grayish-brown calcareous very crumbly clay underlain by limestone at depths ranging from 7 to 18 inches (pl. 3, *B*). The soil is generally suited as cropland but is not highly productive of most crops other than small grains.

Representative profile:

0 to 6 inches, dark-brown calcareous clay; very granular and crumbly.
6 to 14 inches, brown calcareous clay; very granular and crumbly.
14 to 30 inches +, limestone.
VARIATIONS: The color of surface soil ranges from dark brown to dark grayish brown, and in a few places, where the underlying limestone is somewhat chalky, the color is grayish brown; depth to limestone ranges from 7 to 18 inches; included are a few small areas on knolls where limestone is within plow depth.

Location: One of the principal soils of the Grand Prairie.
Relief and Drainage: Gently sloping upland; both runoff and internal drainage are medium.
Erosion: Slight to moderate in cultivated areas.
Parent Material: Limestone.
Native Vegetation: Prairie grasses, largely little bluestem.
Utilization: Principally oats, cotton, and grain sorghums; pasture.
Land Class and Agronomic Group: Third-class; group 12.

EDDY SERIES

The Eddy series consists of light-gray to light brownish-gray highly calcareous soils, mostly very shallow over chalk. These soils are associated with the Austin soils but are lighter colored and shallower.

Eddy gravelly clay loam, 4 to 15 percent slopes (EA).—This is a light brownish-gray very shallow chalky soil on strongly to moderately sloping hills. It is too shallow for cropping but is valuable for pasture.

Representative profile (4 miles west of Eddy):

0 to 4 inches, light brownish-gray calcareous clay loam containing many fine fragments of chalk.
4 to 30 inches +, chalk, slightly weathered and broken to a depth of about 20 inches.
VARIATIONS: The depth to chalk ranges from about 2 to 7 inches; there are a few small included areas in which the soil is grayish brown.

Location: Principal soil of the chalk hills that extend southward from Waco into Bell County.
Relief and Drainage: Moderately to strongly sloping upland; runoff is rapid or very rapid; internal drainage is medium.
Erosion: Very susceptible if cultivated; none to slight in the 68 percent that has not been cultivated; moderate to severe in the 32 percent that has been cropped.

Parent Material: Chalk.
Native Vegetation: Grass with scattered trees of live oak and Texas red oak.
Utilization: Oats and sorghums; pasture.
Land Class and Agronomic Group: Nonarable; group 21.

Eddy gravelly clay loam, 15 to 50 percent slopes (Eb).—This soil occupies steeply sloping areas underlain at very shallow depth by chalk. The areas occur mainly in the belt of chalk hills that begins as bluffs along the Brazos River north of Waco, skirts along the south side of Lake Waco, and continues southward toward Eddy. Smaller areas are northeast of the Brazos River near West and Lakeview. In most places the soil consists of 2 to 5 inches of light brownish-gray calcareous clay loam over chalk. Fragments of chalk are scattered over the surface and throughout the thin layer of soil.

Most of the larger areas are covered with cedar; the smaller areas surrounded by somewhat deeper soils support some grass. This very shallow soil is of low utility for agriculture. The cedar brakes produce fence posts; areas in grass afford sparse pasture. More than 75 percent of the total acreage is under a cedar-oak cover; the rest is in pasture or in urban areas and farmsteads. This soil is only slightly susceptible to erosion under a natural forest cover, and the entire area has slight or no erosion. This nonarable soil is in agronomic group 23.

Eddy silty clay, 8 to 15 percent slopes (Ec).—This is a light brownish-gray very limy mealy silty clay that occurs on hills underlain by chalk or chalky marl. Most areas are severely eroded; all are unsuited as cropland.

Representative profile (3 miles south of Hewitt):

0 to 10 inches, light brownish-gray highly calcareous silty clay or clay; very granular and crumbly.
10 to 30 inches +, chalk.
VARIATIONS: The soil ranges from light gray to light brownish gray; locally it includes a few fine fragments of chalk.

Location: Largest areas are south of Hewitt and Lorena.
Relief and Drainage: Mostly strongly sloping, some moderately sloping; runoff is very rapid and internal drainage is medium.
Erosion: Very susceptible; severe to moderately severe erosion prevails in areas that have been cultivated.
Parent Material: Soft chalk.
Native Vegetation: Prairie grasses.
Utilization: Pasture or idle. About 85 percent of the area has been cropped; most of this is severely eroded idle land or unproductive abandoned-field pasture.
Land Class and Agronomic Group: Nonarable; group 21.

ELLIS SERIES

The soil of the Ellis series is very shallow and noncalcareous and overlies yellow and olive-gray noncalcareous shale. It resembles the Sumter soil in some respects but contains no free lime, is more gummy and less crumbly, and is commonly more olive in color.

Ellis clay, 6 to 15 percent slopes (Ed).—This is a yellowish-brown to olive-brown gummy clay. It is relatively infertile, droughty, and

difficult to work. The areas are moderately to strongly sloping and generally unsuitable as cropland.

Representative profile:

0 to 4 inches, dark yellowish-brown or dark olive-brown noncalcareous gummy clay; slightly acid.
4 to 20 inches, light olive-brown noncalcareous gummy clay.
20 to 60 inches +, light olive-gray noncalcareous shale.
VARIATIONS: Depth to shale varies between about 15 and 35 inches; includes many small areas of calcareous soil.

Location: Restricted to a few areas in the hilly sections between Gholson School and Tokio.

Relief and Drainage: Moderately to strongly sloping upland; runoff is very rapid and internal drainage is deficient or lacking.

Erosion: Very susceptible if cultivated.

Parent Material: Noncalcareous shale.

Native Vegetation: Grass surmounted by tasajillo (*Opuntia leptocaulis*) and elm, which form a fairly thick cover in places.

Utilization: Mainly for pasture; some cultivated areas.

Land Use and Agronomic Group: Nonarable; group 21.

EUFAULA SERIES

The Eufaula series consists of light-colored loose sands more than about 36 inches deep over more loamy or clayey subsoil. It is a slightly darker and slightly less acid equivalent of the Lakeland series of the more humid parts of the Gulf Coastal Plain. It has developed under forest from very sandy sediments washed from western plains, which contain more weatherable minerals than the sands of the Coastal Plain.

Eufaula fine sand, 0 to 2 percent slopes (Ee).—This is a light-colored loose fine sand several feet deep. The soil is susceptible to blowing when cropped; small areas in cultivation are used for peanuts and corn; the rest is woodland pasture or idle. The soil is the most loose and sandy part of the area of deep sands near Gholson School.

Representative profile (in a forested area):

0 to 4 inches, pale-brown or brown loose fine sand; neutral.
4 to 30 inches, very pale-brown loose fine sand; slightly acid.
30 to 50 inches, pale-yellow loamy fine sand; slightly acid.
50 to 60 inches, pale-yellow friable sandy clay loam slightly mottled with reddish yellow; strongly acid.
60 to 90 inches +, pale-yellow loamy fine sand; slightly acid.
VARIATIONS: Depth to sandy clay loam varies from about 40 to 70 inches.

Location: Restricted to one large area near Gholson School, which is a stream divide in an erosional upland discontinuously mantled with alluvium.

Relief and Drainage: Level to undulating upland; runoff is medium, and internal drainage is rapid.

Erosion: Not susceptible to water erosion, but slightly susceptible to wind erosion.

Parent Material: Old sandy alluvium from western plains.

Native Vegetation: Scrub forest of post and blackjack oaks.

Utilization: Peanuts, corn, cowpeas, watermelons, sweetpotatoes, and some cotton.

Land Use and Agronomic Group: Fourth-class; group 17.

HORTMAN SERIES

The Hortman series consists of light-colored acid forested sandy soils. They have clay subsoils that are red in the upper part and mottled red, yellow, and gray below. They are associated with soils of the Axtell series, from which they differ in having redder, somewhat less compact, upper subsoils. The Hortman soils have profiles similar to the Boswell soils, which are not mapped in this county. The Hortman soils, however, have developed in old alluvium brought down by rivers that drain western plains underlain by redbeds.

Hortman fine sandy loam, 2 to 4 percent slopes (HB).—This is a light-colored acid sandy soil with a subsoil of red clay that becomes mottled and more compact at greater depth.

Representative profile in a forested area 8 miles northwest of Waco:

0 to 3 inches, grayish-brown fine sandy loam; neutral.
3 to 8 inches, pale-brown fine sandy loam; slightly acid.
8 to 15 inches, reddish-yellow or red clay; moderately crumbly; slightly acid.
15 to 35 inches, mottled red and pale-yellow compact clay; slightly acid.
35 to 60 inches +, yellow and light-gray compact noncalcareous sandy clay.
VARIATIONS: Depth of the sandy layers over the clay subsoil ranges from about 6 to 12 inches.

Location: A few small, freely drained areas of timbered sandy upland on old stream terraces; representative area is 2 miles south of Harrison.

Relief and Drainage: Gently sloping; drainage is free from the surface, but very slow internally.

Erosion: Moderately susceptible if cultivated.

Parent Material: Sandy clays representing old alluvium of the Brazos River; calcareous in some places, but noncalcareous in others.

Native Vegetation: Scrub-oak forest.

Utilization: Corn, grain sorghums, and native pasture.

Land Use and Agronomic Group: Fourth-class; group 15.

Hortman-Axtell fine sandy loams, 4 to 10 percent slopes (HA).—This is a sloping soil complex on sandy forested upland. The prevailing soils are light-colored relatively infertile fine sandy loams that have subsoils of reddish, more or less mottled, heavy clay. Commonly the sandy layers are 4 to 7 inches deep over the subsoils. The principal soils are Hortman fine sandy loam and Axtell fine sandy loam. The profiles of these are similar to Hortman fine sandy loam and Axtell fine sandy loam where developed in gently sloping areas, except that the several horizons are somewhat thinner. In uneroded places where the sandy surface soil is less than about 5 inches deep, the very pale-brown subsurface layer of fine sandy loam is very thin or wanting.

This complex is poorly suited to crops because of its susceptibility to erosion, low inherent fertility, and shallowness to the claypan-like subsoil. Some small areas can be used as cropland, but most of this complex is best used for pasture and woodlots.

Location: Occupies most of the sloping areas in the sandy timbered uplands near Ross, Tokio, Elm Mott, Harrison, Riesel, Bosqueville, Robinson, Robertson, and Golindo; individual bodies are small or narrow.

Relief and Drainage: Mostly moderately sloping, but some hilly with gradients of 10 to 20 percent; runoff is rapid; internal drainage is slow to very slow.
Erosion: Susceptible to rapid erosion if cropped without careful management; most areas that have been cropped are moderately eroded; 4 percent of the total, distributed in many small areas rarely larger than 5 acres, is severely eroded.
Parent Material: Old Brazos River alluvium of clay or sandy clay; calcareous in some places and noncalcareous in others.
Native Vegetation: Scrub forest of oak.
Utilization: Principally cotton, corn, special crops, and pasture.
Land Use and Agronomic Group: Fourth-class; group 19.

HOUSTON BLACK SERIES

The Houston Black series typifies the very dark-gray to black heavy crumbly limy "black waxy" soils of the Blackland Prairie. The typical soils are deep, nearly level to gently sloping, and highly productive for common field crops. Where the Houston Black series has developed in calcareous olive-colored or yellowish clay or marl, the associated more sloping areas are Houston clays, which are browner colored and darkened to less depth and give way to Sumter clay on severely eroded or steep areas. Where the Houston Black series has developed in chalk or chalky marl, it occupies smooth mostly concave areas. Austin and Eddy soils occupy the convex or more sloping areas.

Houston Black clay, 0 to 1 percent slopes (HE).—This is a very dark-gray to black deep clay of the Blackland Prairie. It is like Houston Black clay, 1 to 4 percent slopes, except in relief. Because of the level topography, it has slow surface drainage and is free from erosion.

Representative profile:

0 to 18 inches, very dark-gray (black when wet) calcareous heavy clay; crumbly and granular.
18 to 40 inches, very dark-gray calcareous heavy clay; less crumbly and more compact than layer above.
40 to 55 inches, dark-gray compact calcareous clay containing scattered concretions of calcium carbonate.
55 to 70 inches, light olive-gray calcareous heavy clay.
70 to 80 inches +, parent material of light-gray and yellow compact clayey marl; nearly impervious.
VARIATIONS: Color of the surface soil ranges from dark gray to black.

Location and Extent: The principal areas are near Mart, Eddy, and West.
Relief and Drainage: Nearly level; both runoff and internal drainage are very slow.
Erosion: Not susceptible.
Native Vegetation: Prairie grasses.
Parent Material: Marine marls and chalks.
Utilization: Principally in cotton, corn, and sorghums.
Land Class and Agronomic Group: First-class; group 4.

Houston Black clay, 1 to 4 percent slopes (HC).—This, the most extensive soil of the Blackland Prairie, is a black deep clay on broad

undulating areas. It is commonly known as heavy blackland or black waxy land. It is well suited to and highly esteemed for crops.

Representative profile:

0 to 18 inches, black or very dark-gray calcareous heavy clay; granular and crumbly.
18 to 35 inches, very dark-gray heavy clay; somewhat compact and less crumbly than layer above.
35 to 60 inches, dark olive-gray calcareous heavy clay containing a few concretions of calcium carbonate; very slowly pervious.
60 to 80 inches +, light olive-gray shaly marl or highly calcareous clay; nearly impervious.
VARIATIONS: Where developed over chalk, the black layer is about 20 inches deep and is underlain by very dark grayish-brown subsoil, and chalk is at depths of 30 to 50 inches; in this variation the subsoil is more crumbly than where the soil developed on clayey marl; many areas include small spots of the Houston clays.

Location: The most extensive soil of the county; large areas near West, Mart, Moody, Spring Valley, and China Spring.

Relief and Drainage: Gently sloping upland; surface drainage is medium; internal drainage is very slow; drainage is generally adequate for best growth of warm-season crops.

Erosion: Slightly to moderately susceptible if cultivated; 58 percent has slight or no erosion; and 42 percent has moderate erosion (the dark layer appreciably thinned; some gullies and rills; productivity lowered appreciably but probably restorable by good soil management).

Parent Material: Marine marl, chalk, or calcareous clay of Gulf Cretaceous formations.

Native Vegetation: Tall prairie grasses.

Utilization: The principal field crops are cotton, corn, grain sorghums, sorgos, oats, sudangrass, and sweetclover, in the approximate order of acreage.

Land Class and Agronomic Group: First-class; group 3.

Houston Black gravelly clay, 1 to 4 percent slopes (HD).—This soil is like Houston Black clay, 1 to 4 percent slopes, but has waterworn gravel on the surface. The gravel, consisting of subrounded fragments of chert mostly from 1 to 3 inches in diameter, occurs only in the plowed layer. It is sufficiently abundant to interfere slightly with cultivation by dulling tools, but otherwise appears to have no practical significance.

The soil is suited to the same crops and gives about the same yields as Houston Black clay, 1 to 4 percent slopes. It erodes about as easily. About 88 percent of this soil is cultivated, and the rest is in pasture. This is a First-class soil and is in agronomic group 3.

Houston Black clay, moderately deep variant, 1 to 4 percent slopes (HF).—This soil differs from typical Houston Black clay in being moderately deep over chalk. Accordingly, there is less storage capacity for moisture, and crops are more affected by droughts than on the other Houston Black clay soils. This soil is suitable as cropland; it is largely in cultivation and is used mainly for cotton farming.

Representative profile (2 miles southwest of Hewitt):

0 to 15 inches, black calcareous heavy clay; granular and crumbly.
15 to 24 inches, very dark grayish-brown calcareous heavy clay.
24 to 30 inches +, hard chalk.

VARIATION: Depth of soil over chalk ranges from 15 to 30 inches; in places the surface soil is very dark brown.

Location: Near West, Hewitt, and Eddy.
Relief and Drainage: Nearly level to very gently sloping upland, with very few gradients of more than 2 percent; surface drainage is mostly slow to medium, and internal drainage is slow.
Erosion: Slightly susceptible.
Parent Material: Moderately hard chalk.
Native Vegetation: Prairie grasses.
Utilization: Principally for cotton; some corn and sorghums.
Land Class and Agronomic Group: Second-class; group 9.

HOUSTON SERIES

The Houston series is made up of limy, heavy but crumbly, brownish-colored clay soils of the Blackland Prairie. They are similar to soils of the Houston Black series but are less dark, generally darkened to less depth, and mostly more sloping and susceptible to erosion.

Houston clay, 1 to 4 percent slopes (Hc).—This is a dark-brown, olive-brown, or dark yellowish-brown, deep, fertile clay. It differs from Houston clay, 4 to 8 percent slopes, in being deeper, and it occupies gently sloping areas where erosion is not so active. It is similar to Houston Black clay but is of somewhat different color; that is, more brownish in all layers. The soil is productive, largely in cultivation, and well suited as cropland.

Representative profile (4 miles southeast of Moody):

0 to 10 inches, dark yellowish-brown calcareous heavy clay; crumbly and granular.
10 to 50 inches, olive-brown calcareous heavy clay; crumbly and granular in the upper part; gradually more compact and less dark with depth.
50 to 65 inches +, light yellowish-brown, heavy, nearly impervious, calcareous clay.
VARIATIONS: Color of surface soil ranges from dark grayish brown to olive brown.

Location: Large areas occur near Moody, China Spring, and West.
Relief and Drainage: Gently sloping upland; surface drainage is medium, and internal drainage is very slow or wanting.
Erosion: Slightly to moderately susceptible; 35 percent of the area has no or slight erosion; 65 percent has moderate erosion (the darkened layer noticeably thinned, and the productivity lowered but probably restorable by good soil management).
Parent Material: Calcareous marine clays of the Eagle Ford formation.
Native Vegetation: Tall prairie grasses.
Utilization: Cultivated land is used mainly for cotton farming; some corn and sorghums.
Land Class and Agronomic Group: First-class; group 3.

Houston clay, 4 to 8 percent slopes (Hh).—This is a dark grayish-brown or olive-brown soil on moderately sloping areas underlain by shaly marl or yellow calcareous clay. It is moderately deep and was originally fertile. If not carefully managed, it erodes rapidly if used for clean-tilled crops. Most areas have been cropped for many years without manuring or protection from erosion and have

become much less productive. The soil is suited to crops, but not to a system of farming that depends almost entirely on cotton, corn, or other intertilled crops. Many areas, particularly those that are more sloping and eroded, can well be used as permanent grassland.

Representative profile (an area of native prairie 3 miles northeast of Leroy):

0 to 10 inches, dark grayish-brown calcareous heavy clay; crumbly and granular; very sticky when wet; surface inch consists of loose, very fine grains.
10 to 20 inches, olive-brown or dark yellowish-brown calcareous heavy clay.
20 to 45 inches, yellowish-brown calcareous heavy clay of cloddy breakage; contains a few concretions of calcium carbonate; somewhat more compact than first two layers.
45 to 150 inches, light-gray and pale-yellow, calcareous, nearly impervious clay.
150 to 250 inches +, unweathered light olive-gray shaly marl.
VARIATIONS: Color of surface soil ranges from dark grayish brown to olive brown.

Location: Scattered throughout the eastern part of the county.
Relief and Drainage: Moderately sloping; the long smooth slopes are suitable for terracing; runoff is rapid; internal drainage is practically wanting.
Erosion: Very susceptible if cultivated; the 15 percent of the area that has not been cultivated is without appreciable erosion; the 85 percent at some time cultivated has moderately severe erosion (the darkened upper layer much thinned, and rills and gullies numerous).
Parent Material: Calcareous marine clays.
Native Vegetation: Tall prairie grasses.
Utilization: Cultivated land mainly in cotton and corn; sorghums and oats occupy moderate acreages; a few areas in native meadows.
Land Class and Agronomic Group: Third-class; group 11.

Houston clay, 8 to 15 percent slopes (Hk).—This soil is like Houston clay, 4 to 8 percent slopes, except that the topography is hilly and the soil layers are somewhat thinner. It comprises areas of dark yellowish-brown clay that are too strongly sloping to be suited to crops. The soil is deep. Native grasses thrive and afford good pasture.

Representative profile (3 miles southeast of Leroy):

0 to 15 inches, dark yellowish-brown calcareous heavy clay; granular and crumbly; very plastic and sticky when wet.
15 to 40 inches, light yellowish-brown calcareous heavy clay; slowly pervious.
40 to 70 inches +, parent material of pale-yellow and light-gray highly calcareous compact clay; nearly impervious.
VARIATIONS: Considerable variations in depth and darkness of soil; areas that have been cultivated include some Sumter clay.

Location: Occurs associated with Houston clay, 4 to 8 percent slopes, and Sumter clay, 8 to 20 percent slopes, mainly in the southeastern parts of the county.
Relief and Drainage: Strongly sloping upland; runoff is very rapid; internal drainage is slow or wanting.

Erosion: Too susceptible to be suitable as cropland; 65 percent, which is mostly pasture, has slight erosion; 35 percent has moderately severe erosion and numerous gullies.
Parent Material: Calcareous marine clays.
Native Vegetation: Tall prairie grasses, originally; now, most pastures are a mixture of buffalograss, grama, and Texas needlegrass.
Utilization: Mainly pasture; some areas in cultivation.
Land Class and Agronomic Group: Nonarable; group 21.

IRVING SERIES

The Irving series consists of gray to dark-gray noncalcareous soils with subsoils of dark-gray, tough, compact clay (pl. 4). The soils occur on old stream terraces in areas that originally were mostly prairie or grassland. The relief is typically level, and runoff is very slow or wanting. These soils belong in the group referred to as tight soils of the grasslands. They are suitable for crops, but as a rule, are more difficult to work and less productive than such deep crumbly blackland soils as the Houston Black clays and Bell clays.

Irving clay loam, 0 to 1 percent slopes (IE).—This is a dark-gray crusty soil that occurs on level parts of old stream terraces. The soil is largely in cultivation and is used mainly for cotton farming.

Representative profile (5 miles east of Waco):

0 to 10 inches, dark-gray noncalcareous clay loam; friable when moist; weakly granular; on drying after rains becomes very hard unless cultivated; neutral.
10 to 18 inches, very dark-gray noncalcareous clay of cloddy breakage; neutral.
18 to 43 inches, dark-gray noncalcareous tough clay.
43 to 60 inches, gray, tough, noncalcareous clay containing a few concretions of calcium carbonate.
60 to 70 inches +, light olive-gray, calcareous, tough clay; very slowly pervious.
VARIATIONS: Thickness of the clay loam surface layer ranges from 5 to 15 inches.

Location: In the eastern part of the county; large areas along Tehuacana Creek.
Relief and Drainage: Level stream terraces; runoff is very slow or wanting; internal drainage is very slow.
Erosion: Not susceptible.
Parent Material: Alluvial sediments of slightly calcareous clay.
Native Vegetation: Mainly grass.
Utilization: Principally cotton; corn and grain sorghums next important in acreage.
Land Class and Agronomic Group: Second-class; group 8.

Irving clay loam, 1 to 3 percent slopes (ID).—This soil occurs on the margins of high stream terraces in association with Irving clay loam, 0 to 1 percent slopes. It differs from that soil in occupying gently sloping areas where surface drainage is medium. Slight to moderate erosion prevails. About 66 percent of the soil has no or slight erosion; and 34 percent, which is on slopes of more than 2 percent, has moderate erosion. The soil is suited to the same crops and yields about the same as Irving clay loam, 0 to 1 percent slopes. Typi-

cal areas occur 6 miles east of Waco. This is a Second-class soil and is in agronomic group 7.

Irving silt loam, 0 to 1 percent slopes (IF).—This tight soil occurs in level slowly drained areas on old stream terraces. It has a gray surface soil, which becomes very hard on drying after rains, and a dark-gray compact subsoil. The soil is not quite so strong as the heavier types of the Irving series. Continued cropping without manuring or fertilization has reduced the productivity to a marked degree. The soil is suitable for crops, but tilth and fertility need to be improved if good yields are to be obtained.

Representative profile:

0 to 10 inches, gray, noncalcareous, crusty silt loam; weakly granular; very slightly acid.
10 to 20 inches, very dark-gray noncalcareous tough clay; neutral.
20 to 33 inches, dark-gray noncalcareous tough clay.
33 to 50 inches, gray noncalcareous tough clay.
50 to 75 inches +, light olive-gray calcareous tough clay; very slowly permeable.
VARIATIONS: In some local areas the surface soil is grayish brown, and the subsoil is gray, mottled with reddish brown.

Location: On stream terraces in the eastern parts of the county; some of the larger areas are near Axtell and a few miles northeast of Waco.
Relief and Drainage: Level. Drainage is very slow from the surface and internally but generally adequate for best growth of warm-season crops.
Erosion: Not susceptible.
Parent Material: Slightly calcareous alluvial clays.
Native Vegetation: Mainly grass.
Utilization: Principally cotton, corn, and sorghums; some pasture.
Land Class and Agronomic Group: Second-class soil; group 8.

Irving-Axtell complex, 0 to 1 percent slopes (IA).—This complex comprises small areas of slowly drained flats occupied by a mixture of several slightly acid moderately sandy soils with heavy very slowly permeable clay subsoils. The areas are parts of old stream terraces and, where uncleared, are occupied by a scrub woods of post oak and elm. The soils are mainly fine sandy loams and loams of the Irving and Axtell series. These differ in color of their surface soil and subsoil, and to a limited degree in fertility. As a whole, however, the several soils have similar crop adaptations and soil management requirements. All are of low or only moderate fertility, have subsoils that are essentially claypans, are more or less acid and relatively low in organic matter, become very hard on drying, and are poorly drained and somewhat difficult to work. Both runoff and internal drainage are very slow. Considerable areas of this complex occur near Harrison, Axtell, Bellmead, Ross, and Tokio.

The most extensive soils of the complex are Irving fine sandy loam and Irving loam. Together, these occupy from one-half to three-fourths of most areas of the complex. Their surface soils are gray, slightly acid, crusty, and 7 to 12 inches deep. The subsoils are dark-gray noncalcareous tough clay. The deep substrata are of gray or light olive-gray slightly calcareous compact sandy clay.

The remaining principal soil of the complex, Axtell fine sandy loam, has a surface layer slightly darker or grayer than the other two. The surface soil is grayish-brown slightly acid fine sandy loam to a depth of about 5 inches, where the color changes to light gray. The subsoil, reached at 7 or 10 inches below the surface, consists of mottled reddish-brown, brownish-yellow, and gray noncalcareous tough sandy clay.

The principal crop is cotton; other important crops are corn, grain sorghums, sorgos, sudangrass, and cowpeas. The prevailing yields are low, and improvement of productivity is rather difficult because of the heavy subsoils. Most pastures are unimproved and produce low-quality grass; hence, the carrying capacity is low. Much better pasture can be established.

This complex is suitable as cropland. It is better suited to cotton and sorghums, which are drought resistant and tolerant of occasional excessive wetness, than it is to corn or small grains. Improved soil management is required for satisfactory yields. Erosion is not a problem because the surface is nearly level. This complex consists of Second-class soils and is in agronomic group 8.

IVANHOE SERIES

The Ivanhoe series is made up of grayish-brown soils that have gray, compact, tough, clay subsoils mottled with reddish brown and brownish yellow. These soils have developed from old alluvium on nearly level terraces of the Brazos River. They are associated with soils of the Irving series, which are darker and have unmottled subsoils, and with Axtell soils, which are lighter colored.

Ivanhoe soils have very slow internal drainage. They are wet in the spring, crusty and hard when dry, and of only moderate fertility. They are of slight extent in this county and are mapped only as a soil complex in close association with small areas of Irving clay loams and Axtell fine sandy loams. Ivanhoe silt loam, the only member of the series in the county, is described under the Ivanhoe-Irving-Axtell complex, 0 to 1 percent slopes.

Ivanhoe-Irving-Axtell complex, 0 to 1 percent slopes (Io).—This level complex consists of intermingled small areas of Ivanhoe silt loam, Irving clay loam, and somewhat more sandy soils that are largely of the Axtell series. The areas are level poorly drained flats on terraces along the Brazos River. They differ from areas classed as Irving-Axtell complex in being somewhat less sandy and more fertile. The Ivanhoe silt loam member of this complex is closely related to the Irving soils and has developed from like parent materials. It differs from the Irving soils mainly in having a mottled subsoil.

Representative profiles:

Ivanhoe silt loam:
- 0 to 12 inches, grayish-brown noncalcareous silt loam; moderately granular; very slightly acid.
- 12 to 18 inches, mottled gray, light-gray, and reddish-brown noncalcareous clay loam; moderately friable.
- 18 to 40 inches, light brownish-gray noncalcareous clay mottled with brown and brownish yellow; compact and very slowly permeable.
- 40 to 70 inches, light olive-gray noncalcareous clay; compact.
- 70 to 90 inches +, light olive-gray slightly calcareous clay with occasional lenses of reddish-brown silty clay.

Irving clay loam and Axtell fine sandy loam:
Described under types of Irving and Axtell named in this report.
VARIATIONS: Cultivated fields have a spotted appearance because of differences in color of the surface soil of the small intermixed areas of the component soils.

Location: Covers a few fairly large areas on relatively low terraces along the Brazos River, the largest being 4 miles north of Waco.
Relief and Drainage: Level; the Irving soils occupy slight swales where water collects; the others are on slight elevations.
Erosion: Not susceptible.
Parent Material: Alluvial clays, largely from the Brazos River.
Native Vegetation: Mostly prairie.
Utilization: Principally cotton, corn, and sorghums; pasture.
Land Class and Agronomic Group: Second-class; group 8.

KAUFMAN SERIES

In the Kaufman series are dark noncalcareous alluvial soils that occur in periodically flooded first bottoms. They are on stream sediments that originated mainly in areas of Wilson and related tight soils that developed under a grass cover. The Kaufman soils are fertile, moderately well drained, and commonly are the most productive cropland in the localities where they occur. Kaufman soils, as they were mapped in this county, would now be correlated in the Gowen series.

Kaufman clay loam, 0 to 1 percent slopes (KA).—This is a dark noncalcareous bottom-land soil with a subsoil of moderately permeable clay loam. It occurs on flood plains of streams in eastern parts of the county. These streams drain mixed areas of sandy timbered uplands and tight grasslands. The soil resembles the Catalpa clay loams but is noncalcareous.

Representative profile:

0 to 48 inches +, dark grayish-brown noncalcareous clay loam; neutral; crumbly, friable, and permeable.
VARIATIONS: Locally the soil material is stratified with slightly sandier or heavier material; small areas of calcareous soils, Catalpa clay loams, are included in the areas as mapped.

Location: The principal areas are in the flood plain of Trading House Creek; smaller areas occur along other streams in the eastern part of the county.
Relief and Drainage: Nearly level flood plain; runoff is slow; internal drainage is medium; floods occur nearly every year.
Erosion: Not susceptible.
Parent Material: Recent stream sediments.
Native Vegetation: Hardwood forest.
Utilization: Principally cotton and corn; pasture.
Land Class and Agronomic Group: Third-class; group 14.

Kaufman loam, 0 to 1 percent slopes (KB).—This soil is similar to Kaufman clay loam, 0 to 1 percent slopes, except for containing more sand. It occurs on narrow flood plains along some small streams that drain mixed areas of timbered sandy uplands and tight grasslands. One of the larger tracts is 5 miles west of Riesel. The soil is a grayish-brown or dark grayish-brown noncalcareous loam several feet

deep. Locally there is some stratification with fine sandy loam and clay loam.

The soil is fertile and easily worked; it is well suited to crops. Most areas are surrounded by sloping soils poorly suited to cultivation and remain uncleared. Some areas, however, are used for growing corn and cotton. About 60 percent is in pasture and is well suited to this use. This Third-class soil is in agronomic group 14.

KRUM SERIES

The Krum series consists of dark grayish-brown, very granular, calcareous soils that have developed on old alluvial fans and narrow valleys surrounded by sloping limestone prairies. The parent material is grayish-brown or yellowish-brown, strongly calcareous, friable alluvium washed from higher lying slopes of Tarrant, Denton, and Brackett soils. Krum soils are deep, crumbly, and granular. They are similar to the Lewisville soils, but occur in narrow steep-walled limestone valleys that are usually cut by deep gullies or stream channels.

Krum clay, 4 to 8 percent slopes (Kc).—This soil occurs in sloping narrow valleys in the Grand Prairie. It is capable of producing good yields of field crops, but the areas are too small for convenient laying out of fields and are interrupted by deep natural gullies. The soil is therefore best used for pasture. In most places this soil is the only deep soil in the pastures where it occurs. It is therefore particularly valuable, since the grasses continue growth on it longer during droughts than on the large areas of associated stony lands.

Representative profile:

0 to 10 inches, dark grayish-brown calcareous silty clay or light clay; very granular and crumbly.
10 to 25 inches, grayish-brown calcareous silty clay or light clay; very granular and crumbly.
25 to 50 inches, brown calcareous silty clay or light clay; very granular.
50 to 70 inches +, yellowish-brown silty clay or light clay containing scattered concretions of calcium carbonate; this parent material is local alluvium from adjoining limestone slopes; rests on limestone at depths ranging from 4½ to 6 feet.
VARIATIONS: The areas include narrow strips of broken land that constitute deep natural gullies.

Location: Sloping floors of narrow valleys in the stony parts of the Grand Prairie.

Relief and Drainage: Moderately sloping (concave slopes) with gradients of 4 to 8 percent; runoff and internal drainage are medium to rapid.

Erosion: Very susceptible if cultivated, because of its position and sloping surface; all areas receive extra water as runoff from higher lying shallow soils; most areas have a central V-shaped gully, which is the natural drainageway.

Parent Material: Local alluvium mostly from Tarrant stony clays.

Native Vegetation: Originally tall prairie grasses; most pastures now have an almost solid sod of buffalograss.

Utilization: Mainly pasture; small acreage in cotton, corn, and oats.

Land Class and Agronomic Group: Third-class; group 11.

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LEWISVILLE SERIES

The Lewisville series consists of dark-brown to dark grayish-brown, limy, very crumbly soils of the stream terraces. They are associated mainly with soils of the Bell series, from which they differ in being browner, more rapidly drained both from the surface and internally, and more crumbly and friable. They are fertile, easily worked, largely in cultivation, and highly esteemed as cropland.

Lewisville clay, 0 to 1 percent slopes (LB).—This is a dark-brown granular clay on the stream terraces that, for the most part, were originally prairies. Practically all the soil is in cultivation.

Representative profile:

0 to 12 inches, dark grayish-brown highly calcareous silty clay or clay; very granular and crumbly.
12 to 30 inches, dark-brown to brown highly calcareous silty clay or clay; very granular; permeable.
30 to 70 inches +, parent material of light-brown highly calcareous silty clay or clay; contains an occasional waterworn pebble of limestone.
VARIATIONS: Color of surface soil ranges from dark grayish brown to dark brown.

Location: On stream terraces, principally along the several forks of the Bosque River; one of the largest areas is 3 miles north of South Bosque School.
Relief and Drainage: Level or nearly level; runoff is slow and internal drainage is medium.
Erosion: Not susceptible.
Parent Material: Highly calcareous friable alluvial clays from prairies underlain by chalk or limestone.
Native Vegetation: Mostly grass.
Utilization: Cotton, corn, grain sorghums, and oats.
Land Class and Agronomic Group: First-class; group 5.

Lewisville clay, 1 to 4 percent slopes (LA).—This is a brownish, granular, calcareous, clayey soil that occupies gently sloping, low to moderately high, old stream terraces along the several branches of the Bosque River in the central part of the county. It is associated with Bell clays and with other Lewisville soils. Except for being gently sloping and somewhat susceptible to erosion, it is like Lewisville clay, 0 to 1 percent slopes. The prevailing gradient is less than 2 percent. The soil has essentially the same profile, productivity, and utilization as the level phase of Lewisville clay, but it is slightly to moderately susceptible to erosion. About 67 percent is free from appreciable erosion. About 33 percent is moderately eroded, and here the dark surface layer is about three-fourths as thick as in uneroded areas. These moderately eroded areas have not been seriously damaged, and their productivity can be restored by good management. This soil is very good for all general crops. It is a First-class soil and is in agronomic group 5.

Lewisville clay, 4 to 8 percent slopes (LC).—This soil is similar in profile to the less sloping phases of Lewisville clay. It occupies sloping areas and has somewhat thinner soil layers. It is a dark-brown or dark grayish-brown clay. The soil is fertile, deep, and well suited to crops. However, unless carefully managed, it is susceptible to considerable erosion when cropped. Yields vary widely with the

severity of erosion and type of management. On new land, yields approximate those obtained on Lewisville clay, 0 to 1 percent slopes. Since most of the areas are surrounded by large smooth bodies of fertile soils less susceptible to erosion, much of the soil can best be used as permanent pasture or meadow.

Representative profile in a grass-covered area:

0 to 7 inches, dark grayish-brown calcareous silty clay or clay; very granular and crumbly.
7 to 20 inches, dark-brown calcareous silty clay or clay; very granular and crumbly; permeable.
20 to 100 inches +, light-brown or light yellowish-brown highly calcareous clay; freely permeable and friable; contains a few waterworn pebbles of chalk.
VARIATIONS: In cultivated areas the surface soil is brown or grayish brown and, owing to thinning by erosion, the light-brown substratum lies within 12 to 18 inches of the surface; in local areas beds of limestone gravel occur at depths below 30 inches.

Location: Narrow areas on moderately sloping edges of stream terraces.
Relief and Drainage: Moderately sloping; runoff is rapid; internal drainage is medium.
Erosion: Very susceptible if cultivated; 26 percent of soil, which is mostly in native pasture, is unaffected by appreciable erosion; and 74 percent is moderately severely eroded (the dark surface layer is about half as thick as in uneroded areas, and numerous rills and some gullies occur); careful management and measures for controlling erosion are needed to prevent further reduction in productivity.
Parent Material: Friable highly calcareous alluvial clays.
Native Vegetation: Mostly grass.
Utilization: Mainly cotton, oats, corn, and sorghums; pasture.
Land Class and Agronomic Group: Third-class; group 11.

Lewisville clay loam, 1 to 4 percent slopes (LD).—This soil is very similar to Lewisville clay, 1 to 4 percent slopes, but it contains slightly more sand, is more friable, and as a rule is somewhat grayer. This deep clay loam occurs on stream terraces, mainly along the Bosque River.

Representative profile (1 mile northwest of China Spring):

0 to 10 inches, dark grayish-brown highly calcareous clay loam; very granular and crumbly.
10 to 22 inches, grayish-brown highly calcareous sandy clay; granular and crumbly; freely permeable.
22 to 40 inches +, pale-brown friable highly calcareous clay loam.
VARIATIONS: The color of surface soil ranges from dark grayish brown to grayish brown; most areas have some limestone gravel below a depth of 3 to 6 feet.

Location: Many areas are on the very high stream terrace that occupies the divide between the Brazos and North Bosque Rivers near China Spring; others are on low terraces, mostly along the North Bosque.
Relief and Drainage: Gently sloping; a few areas on low terraces are nearly level; runoff and internal drainage are medium.
Erosion: Slightly to moderately susceptible; 62 percent has no or slight erosion and 38 percent has moderate erosion.
Parent Material: Highly calcareous sandy clays of alluvial origin.

Native Vegetation: Mainly grass.
Utilization: Principally in cotton, corn, sorghums, and oats; pasture.
Land Class and Agronomic Group: First-class; group 5.

Lewisville clay loam, 4 to 8 percent slopes (LE).—This soil resembles Lewisville clay loam, 1 to 4 percent slopes, but it is more sloping, erodes more readily, and has somewhat thinner soil layers. In most features it is similar to Lewisville clay, 4 to 8 percent slopes, but it differs in containing more sand. It is suitable for crops but requires rather careful management to prevent erosion and to maintain soil fertility. Most areas can well be used as permanent pasture.

Representative profile:

0 to 18 inches, grayish-brown calcareous clay loam; very granular and crumbly.
18 to 40 inches +, light-brown or light yellowish-brown highly calcareous clay loam; freely permeable.
VARIATIONS: Depth of surface soil varies from about 12 to 20 inches; in many places beds of limestone gravel underlie this soil at depths below 3 feet; in severely eroded places the surface soil is light brown or light yellowish brown.

Location: On margins of high stream terraces; a representative area is 4 miles west of China Spring.
Relief and Drainage: Moderately sloping; runoff is rapid and internal drainage is medium.
Erosion: Very susceptible when cultivated; mostly moderately severely eroded and has scattered gullies and numerous rills; small included areas are severely eroded.
Parent Material: Highly calcareous sandy clays of alluvial origin.
Native Vegetation: Mostly grass with scattered live oak trees.
Utilization: Principally for cotton, grain sorghums, and oats; pasture.
Land Use and Agronomic Group: Third-class; group 11.

MILAM SERIES

The Milam series consists of light-colored forested sandy soils with yellowish-red or red friable sandy clay loam subsoils. They occupy freely drained areas on old stream terraces. These soils have only moderate inherent fertility but have favorable physical characteristics and respond well to soil management.

Milam fine sandy loam, 1 to 4 percent slopes (MA).—This is a deep soil with a light-colored sandy surface layer underlain by a permeable subsoil of reddish friable sandy clay loam. It is particularly adapted to truck crops, fruit, and such special crops as peanuts and cowpeas.

Representative profile (a forested area):

0 to 3 inches, dark grayish-brown light fine sandy loam; slightly acid.
3 to 18 inches, yellow or very pale-brown light fine sandy loam; strongly acid.
18 to 42 inches, red sandy clay loam: strongly acid; moderately permeable and friable.
42 to 66 inches, yellowish-red fine sandy loam high in clay; strongly acid.
66 to 80 inches +, reddish-yellow sandy loam stratified with some white sand and fine gravel.
VARIATIONS: Contains much fine gravel of chert and quartzite in those places indicated by gravel symbols on the soil map.

Location: Undulating areas on moderately high to very high stream terraces along the Brazos River; the principal areas are northeast of Waco, north of Gholson School, and near Asa.
Relief and Drainge: Gently sloping; runoff and internal drainage are medium.
Erosion: Slightly susceptible; 90 percent has no or slight erosion; 10 percent has moderate erosion (productivity lowered no more than 10 to 20 percent).
Parent Material: Old sandy alluvium of the Brazos River; calcareous in some places and noncalcareous in others.
Native Vegetation: Oak forest.
Utilization: Principally peanuts, corn, cowpeas, cotton, sweetpotatoes, peaches, and sorghums; pasture; forest.
Land Use and Agronomic Group: Third-class; group 13.

Milam fine sandy loam, 4 to 8 percent slopes (MB).—This soil occurs on moderately sloping margins of old stream terraces. Some of the larger areas are near the Brazos River southwest of Riesel; others are near Waco. The profile is like that of Milam fine sandy loam, 1 to 4 percent slopes, though the layers are commonly slightly thinner. It is suitable for crops to limited degree but requires improved soil management for good yields. Some tracts are particularly suited to peaches and other tree fruits because of favorable air drainage and somewhat less frost hazard than in lower areas.

This soil, because of slope, erodes moderately where cultivated. About 33 percent, which is mainly in woodland and pasture, has no or slight erosion, and 67 percent has moderately severe erosion. Scattered gullies and numerous rills are common, and measures to reduce erosion are needed if this soil is kept in cultivation. This is a Fourth-class soil and is in agronomic group 19.

Milam loamy fine sand, 1 to 4 percent slopes (MC).—This is a deep rather loose soil that occurs on some of the more sandy areas on terraces along the Brazos River. It is very responsive to management and well suited to peanuts, cowpeas, sweetpotatoes, watermelons, peaches, and other special crops.

Representative profile (1 mile northwest of Gholson School):

0 to 4 inches, grayish-brown slightly acid loamy fine sand; very mellow and almost loose.
4 to 20 inches, very pale-brown or light yellowish-brown strongly acid loamy fine sand.
20 to 38 inches, reddish-yellow or light-brown strongly acid fine sandy loam.
38 to 50 inches, red or yellowish-red strongly acid loam or sandy clay loam.
50 to 80 inches +, yellowish-red slightly acid loamy fine sand.
VARIATIONS: Thickness of the combined loamy fine sand surface and subsurface layers ranges from about 15 to 30 inches; in cultivated fields the plowed layer, extending to depths of 6 to 8 inches, is light brownish gray.

Location and Extent: Occurs on high to low terraces of the Brazos River; the largest areas are near Gholson School; others are southeast of Waco.
Relief and Drainage: Mostly gently undulating; a few moderately sloping areas totaling 150 acres are included; runoff and internal drainage are medium.

Erosion: Not susceptible to water erosion; some soil blowing occurs where clean cultivation is practiced.
Parent Material: Old sandy alluvium of the Brazos River.
Native Vegetation: Oak forest.
Utilization: Mainly corn, peanuts, cotton, cowpeas, watermelons, and sweetpotatoes; pasture; woodland.
Land Class and Agronomic Group: Fourth-class; group 17.

MILLER SERIES

The Miller series is made up of more or less reddish, calcareous, alluvial soils with clay subsoils. These soils are but slightly modified sediments along streams, such as the Brazos River, that drain western plains underlain by reddish-colored rocks.

Miller clay, 0 to 1 percent slopes (MD).—This soil is confined to the flood plain of the Brazos River. It is deep, very fertile, limy, crumbly, and adequately drained for crops. Occasional floods occur but complete loss of crops from overflows is rare. Except for a few low areas recently formed by changes in the channel of the Brazos River, practically all of the soil is in cultivation and highly productive.

Representative profile:

0 to 20 inches, dark-brown calcareous clay or silty clay; granular and crumbly.
20 to 60 inches +, reddish-brown calcareous clay or silty clay; crumbly and not impervious; underlain at greater depths by sands and silts.
VARIATIONS: In some places, mainly on low areas formed by recent changes in the river channel, the subsoil is stratified with sandy loam or silt loam below a depth of 20 inches.

Location: First bottoms of the Brazos River; the largest areas are 5 to 10 miles south of Waco.
Relief and Drainage: Nearly level flood plain, occasionally flooded; surface drainage is slow; internal drainage is slow but adequate for all crops commonly grown.
Erosion: Not subject to erosion.
Parent Material: Recent sediments of the Brazos River.
Native Vegetation: Hardwood forest.
Utilization: The only extensive crops are cotton and corn; some pasture and forest.
Land Class and Agronomic Group: First-class; group 2.

NORGE SERIES

The Norge series consists of moderately sandy to moderately fine-textured, dark-colored soils with stiff but moderately permeable reddish-brown clayey subsoils. They have developed on calcareous sandy clays and clays in well-drained areas under mixed grass and trees. The Norge soils are related to but darker colored than the Travis soils and are more reddish than the associated Payne soil.

Norge clay loam, 1 to 4 percent slopes (NA).—This is a dark reddish-brown to dark-brown crumbly soil that occupies areas transitional between forest and grassland on the old stream terraces. It is fertile, readily worked, and productive for most field crops.

Representative profile:

0 to 7 inches, dark-brown noncalcareous clay loam; neutral; granular and crumbly.
7 to 14 inches, dark reddish-brown noncalcareous granular clay; neutral.
14 to 30 inches, reddish-brown noncalcareous stiff clay; neutral.
30 to 40 inches, yellowish-red noncalcareous stiff clay.
40 to 72 inches +, light reddish-brown friable highly calcareous clay or silty clay containing a few pieces of waterworn limestone gravel.
VARIATIONS: In some places the substratum is limestone gravel or chalk.

Location: Associated mainly with Payne clay loam on old high stream terraces between Bosqueville and Erath; smaller areas occur on other high terraces along the Brazos River.
Relief and Drainage: Gently sloping; both runoff and internal drainage are medium.
Erosion: Moderately susceptible.
Parent Material: Permeable limy earths comprising old alluvium.
Native Vegetation: Mostly grass; mixed trees and grass in some areas.
Utilization: Largely in cotton, corn, and sorghums; some native pasture, about half of which has a fairly thick tree cover.
Land Class and Agronomic Group: First-class; group 5.

Norge fine sandy loam, 1 to 4 percent slopes (NB).—This is a brown soil that occurs on transitional forest-grassland areas. It is fertile, easily worked, and productive for a wide variety of crops.

Representative profile (2 miles south of Waco):

0 to 12 inches, brown friable fine sandy loam; very slightly acid.
12 to 40 inches, reddish-brown noncalcareous sandy clay; stiff but crumbly and moderately permeable; very slightly acid.
40 to 60 inches, light reddish-brown noncalcareous sandy clay; neutral.
60 to 100 inches +, yellowish-red highly calcareous loam.
VARIATIONS: Color of surface soil ranges from dark brown to light brown; thickness ranges from 8 to 15 inches.

Location: Relatively inextensive areas on old high stream terraces; principal areas are 2 miles south of Waco and near Chalk Bluff, 6 miles north of Waco.
Relief and Drainage: Gently sloping; both runoff and internal drainage are medium.
Erosion: Moderately susceptible if cultivated; 40 percent has no or slight erosion, and 60 percent has moderate erosion; scattered gullies and rills are common on the more sloping areas.
Parent Material: Calcareous sandy clays of old stream terraces.
Native Vegetation: Mixed grass-and-oak forest.
Utilization: Mainly common field crops; some fruit and truck crops and pasture.
Land Class and Agronomic Group: First-class; group 6.

NORWOOD SERIES

The soils of the Norwood series occur in the Brazos River flood plain and are subject to periodic overflow. They are brown to reddish-brown calcareous alluvial soils that consist of recent sediments deposited by the Brazos River. They differ from the Asa soils in being of more recent sediments that lack a darkened surface layer, and from the Yahola soils in having medium to moderately fine textured rather than sandy subsoils. The fertile Norwood soils are well suited to a wide

variety of crops. They are some of the most productive soils in the county.

Norwood silt loam, 0 to 1 percent slopes (Nc).—This is a deep well-drained limy soil of the first bottoms of the Brazos River. It consists of river silts deposited during the occasional overflows.

Representative profile:

0 to 70 inches +, reddish-brown calcareous friable silt loam.
VARIATIONS: In places that are gradational to Asa silt loam the surface soil is slightly darkened (brown to dark brown to a depth of 10 to 20 inches).

Location: Flood plain of the Brazos River.
Relief and Drainage: Nearly level flood plain; surface drainage is slow to medium, and internal drainage is moderately rapid; floods occur once in 2 to 5 years.
Erosion: Not susceptible to erosion.
Parent Material: River silts originating in mixed areas of dark prairies and Red Plains.
Native Vegetation: Hardwood forest.
Utilization: Mostly cropland; principal crops are cotton, corn, and alfalfa; some vegetables for market are grown near Waco; pasture.
Land Class and Agronomic Group: First-class; group 1.

Norwood silty clay loam, 0 to 1 percent slopes (Nd).—This is a deep reddish-brown limy soil of the Brazos bottoms.

Representative profile:

0 to 50 inches +, reddish-brown calcareous silty clay loam; permeable; friable and crumbly.
VARIATIONS: In places the soil is slightly stratified with silt loam and silty clay; sands commonly underlie the soil at depths of about 6 feet; color of the surface 10 to 20 inches ranges from reddish brown to brown.

Location: Flood plain of the Brazos River.
Relief and Drainage: Level areas; runoff is slow and internal drainage is medium; adequately drained for all crops commonly grown.
Erosion: Not susceptible.
Parent Material: Recent alluvium of the Brazos River.
Native Vegetation: Hardwood forest.
Utilization: Principally cotton, corn, and alfalfa; pasture; woodland.
Land Class and Agronomic Group: First-class; group 1.

PATRICK SERIES

The Patrick series consists of dark-brown or dark grayish-brown calcareous very granular soils underlain at depths of 30 inches or less by beds of limestone gravel. They are related to the Lewisville soils but are differentiated by their shallow depth to gravel. The gravel substratum makes them droughty or, where very shallow, unsuited as cropland.

Patrick clay, 1 to 4 percent slopes (Pa).—This is a dark grayish-brown limy very crumbly clay underlain by beds of limestone gravel at depths between about 12 and 30 inches. The soil is largely in cultivation but is somewhat droughty and less productive than the deep crumbly blackland soils. It is similar to the deeper areas of Denton clay, shallow variant, 1 to 4 percent slopes, in productivity, crop adaptations, and soil management requirements.

Representative profile (9 miles west of Waco near Harris Creek):

0 to 16 inches, dark grayish-brown calcareous clay; very granular and crumbly.
16 to 20 inches, brown calcareous clay; very granular and crumbly.
20 to 70 inches +, a bed of limestone gravel containing little fine earth.
VARIATIONS: Color of the surface soil ranges from dark brown to very dark grayish brown; a few small areas with clay loam surface soil, totaling 300 acres, are included.

Location: Terraces along streams that drain limestone prairies; a representative area is on the northwest side of Harris Creek just north of the Waco-McGregor highway.

Relief and Drainage: Gently undulating, gradients mostly less than 2 percent; runoff and internal drainage are medium.

Erosion: Slightly to moderately susceptible; 67 percent has no or slight erosion, and 33 percent has moderate erosion; the more sloping cultivated areas are most affected.

Parent Material: Limestone gravel intermixed with some light-brown clay.

Native Vegetation: Mostly grass; some elm, pecan, and hackberry trees.

Utilization: Mainly for field crops, including much oats and generally including corn where feasible; most of the rest is native pasture of excellent quality.

Land Class and Agronomic Group: Second-class; group 9.

Patrick gravelly clay, 2 to 15 percent slopes (PB).—This is a dark-brown gravelly clay underlain by beds of limestone gravel at depths of 5 to 12 inches. It is so gravelly that tillage is very difficult and so shallow that crops do not produce well even during years of high rainfall. It supports nutritious grasses and is valuable for permanent pasture. Some areas in association with deeper soils are cultivated, but yields are very low.

Representative profile (near Hog Creek 5 miles north of Crawford):

0 to 10 inches, dark-brown calcareous gravelly clay; very crumbly and granular; the pebbles are small waterworn fragments of limestone and make up between one-third and two-thirds of the volume.
10 to 60 inches +, a bed of waterworn limestone gravel containing only a small proportion of fine earth.
VARIATIONS: Color of the soil varies from dark brown to dark grayish brown; in some places the fine earth is of clay loam texture; in many places the upper part of the gravel bed is cemented by calcium carbonate into a caliche conglomerate; locally the gravel beds rest on limestone bedrock at shallow depths.

Location and Extent: Small areas on low and high terraces of streams that drain the Grand Prairie; many of the areas are narrow escarpments.

Relief and Drainage: Gently to strongly sloping; runoff is medium to very rapid; internal drainage is rapid.

Erosion: Nearly all in native grass and free from appreciable erosion. The 15 percent that has been cultivated is slightly to moderately eroded.

Parent Material: Limestone gravel.

Native Vegetation: Mostly short grasses; live oak trees are characteristic.

Utilization: Mainly in native pasture; some in cultivation.
Land Class and Agronomic Group: Nonarable; group 21.

PAYNE SERIES

The Payne series consists of dark grayish-brown noncalcareous soils that have very slowly permeable subsoils of brownish clay. The soils have developed in slowly but rather freely drained areas on old stream terraces. They are intermediate in character between the Lewisville and Irving soils, with which they are associated. The subsoils are browner than those of the Irving series and not quite so compact. They are noncalcareous and are less granular than those of the Lewisville series.

Payne clay loam, 1 to 2 percent slopes (Pc).—This soil is deep, moderately fertile, very largely in cultivation, and well liked by farmers.

Representative profile (½ mile west of Bosqueville):

0 to 8 inches, dark grayish-brown or grayish-brown noncalcareous clay loam; slightly acid; weakly granular; slightly crusty.
8 to 20 inches, dark-brown noncalcareous heavy clay; compact; weakly blocky.
20 to 36 inches, brown compact noncalcareous clay slightly mottled with gray; fine cloddy breakage.
36 to 45 inches, brown calcareous moderately compact clay.
45 to 80 inches +, light yellowish-brown highly calcareous friable clay or silty clay; permeable.
VARIATIONS: Subsoil varies from only slightly compact in local places that are transitional to Lewisville soils to very compact in places transitional to Irving; a few small areas have surface soil of silt loam and are inclusions of Payne silt loam.

Location: Mostly large areas on high terraces near Bosqueville and China Spring.
Relief and Drainage: Very gently sloping, gradients mostly less than 2 percent and nowhere more than 3; surface drainage is slow to medium and internal drainage is slow.
Erosion: Slightly to moderately susceptible; moderate erosion, which is confined to the most sloping cultivated areas.
Parent Material: Calcareous alluvial clays.
Native Vegetation: Prairie grasses.
Utilization: Mainly for cotton farming; principal crops are cotton, corn, sorghums, and oats; pasture.
Land Class and Agronomic Group: Second class; group 7.

PLEDGER SERIES

The Pledger series consists of alluvial soils made up of a mixture of clayey sediments from the Red Plains and the dark prairies. The soils have very slow surface and internal drainage and are characterized by black or nearly black calcareous surface soil and reddish clayey subsoil.

Pledger clay, 0 to 1 percent slopes (Pd).—This is a black or very dark-brown limy clay underlain by reddish-brown clay. It occurs in first bottoms and is a mixture of black sediments from prairie streams, such as Aquilla and Tehuacana Creeks, with more reddish sediments from the Brazos River. The areas are flooded rather fre-

quently. As the soil has little runoff or internal drainage, the fields dry very slowly after floods recede. Most areas are cultivated but are so frequently flooded and poorly drained that crop production is difficult and somewhat hazardous. The utilization, drainage, and crop adaptations of this soil are much the same as for Trinity clay, 0 to 1 percent slopes, from which this soil differs in having a reddish subsoil.

Representative profile (near mouth of Aquilla Creek):

0 to 24 inches, black calcareous heavy clay; very sticky and plastic when wet; crumbly.
24 to 60 inches +, reddish-brown calcareous heavy clay; very slowly permeable.
VARIATIONS: The color of surface soil ranges from very dark gray to black; depth to reddish clay ranges from about 20 to 40 inches.

Location: Frequently flooded large areas in first bottoms where the larger streams from the Blackland Prairie, such as Tehuacana and Aquilla Creeks, flow into the Brazos River.
Relief and Drainage: Level flood plain; both surface and internal drainage are very slow; floods occur nearly every year and often last for several days.
Erosion: Not susceptible.
Parent Material: Mixed recent alluvial sediments from the Brazos River and streams of the Blackland Prairie.
Native Vegetation: Hardwood forest.
Utilization: Mainly in cultivation; principal crop is cotton followed by corn and grain sorghums; some pasture and hardwood forest.
Land Class and Agronomic Group: Third-class; group 14.

RIESEL SERIES

The Riesel series consists of grayish-brown to brown noncalcareous soils with compact subsoils of brown heavy clay strongly mottled with reddish brown and yellow. They have developed in rolling to undulating upland from old alluvium of gravelly clay. These soils occupy transitional areas between forest and grassland; they differ from the rather closely related Axtell soils in having a darker surface soil and in lacking a light-colored subsurface layer.

Riesel-Axtell gravelly loams, 1 to 4 percent slopes (RA).—This gently sloping complex consists of intermingled areas of Riesel gravelly loam and Axtell gravelly loam. It is characterized by dark grayish-brown or grayish-brown surface soils, mottled heavy subsoils, and an abundance of gravel. It occurs on gently sloping knolls and transitional areas where more sandy forested upland grades into prairies. The soils are difficult to work and of low to only medium fertility.

Representative profile of Riesel gravelly loam:

0 to 10 inches, dark grayish-brown noncalcareous gravelly loam; the gravel consists of pebbles of quartzite and other acidic rocks.
10 to 18 inches, brown, noncalcareous, compact gravelly clay strongly mottled with red, gray, and dark yellow; slowly pervious.
18 to 30 inches, yellowish-brown compact gravelly clay mottled with gray and reddish brown; noncalcareous.
30 to 50 inches +, light-gray and olive-yellow calcareous compact gravelly clay.

Representative profile of Axtell gravelly sandy loam:

(The Axtell member of the complex differs from typical Axtell soils described elsewhere in this report in having much gravel in the surface and subsoil layers. It is light colored and more sandy than Riesel gravelly loam and occupies slightly higher positions.)

VARIATIONS: Color of the surface soil ranges from grayish brown to very dark grayish brown; much variation in the depth of soil, amount of gravel, color of the subsoil, and depth to calcareous material; an inclusion consists essentially of beds of fine gravel that contain little fine soil and has no well-defined heavier subsoil.

Location: Scattered small areas within and around the margins of very old high terraces near Ross, Tokio, Axtell, Riesel, and Robinson.

Relief and Drainage: Gently sloping; runoff is medium and internal drainage is very slow.

Erosion: Slightly to moderately susceptible.

Parent Material: Gravel and gravelly clays of alluvial origin; in many places the old gravelly alluvium is thin over marl or calcereous clay.

Native Vegetation: Scrub forest of oaks and ground cover of grasses.

Utilization: Cultivated land used mainly for cotton, corn, and sorghums; pasture; native scrub forest.

Land Class and Agronomic group: Fourth-class; group 15.

Riesel-Axtell gravelly loams, 4 to 8 percent slopes (RB).—This sloping complex is like Riesel-Axtell gravelly loams, 1 to 4 percent slopes, except in relief. As a rule, it has a somewhat thinner surface soil, commonly 5 to 8 inches deep. This complex occurs in small scattered areas where very old high terraces merge with the upland. It is very poorly suited as cropland because of the difficulty of tillage caused by abundance of gravel, the rather low fertility, and the susceptibility to erosion. Some small areas are cropped but produce low yields. Although this complex is not good grassland, it seems somewhat better suited to permanent pasture than to any other agricultural use. Both the native scrub forest and areas of abandoned cropland are pastured. This is a Fourth-class soil and is in agronomic group 19.

Riesel-Irving gravelly clay loams, 1 to 4 percent slopes (RC).—This complex occupies gently sloping small areas of gravelly clay loams of the Riesel and Irving series. The soils are somewhat difficult to work because of the abundance of gravel, but produce good crops of cotton, corn, and sorghum.

Representative profile of Riesel gravelly clay loam:

0 to 10 inches, very dark grayish-brown noncalcareous gravelly clay loam; granular and crumbly; the gravel is of fine waterworn fragments of quartzite and other acidic rocks.

10 to 20 inches, reddish-brown, noncalcareous gravelly clay mottled with other shades of brown and light gray; compact; strongly blocky.

20 to 36 inches, mottled yellow and gray noncalcareous compact gravelly clay.

36 to 50 inches +, light olive-gray highly calcareous compact sandy clay containing some fine gravel.

Representative profile of Irving gravelly clay loam:

0 to 6 inches, dark-gray noncalcareous gravelly clay loam.

6 to 20 inches, very dark-gray or nearly black noncalcareous compact gravelly clay.

20 to 40 inches, olive-gray noncalcareous compact clay containing some fine gravel.
40 to 60 inches +, pale-olive, calcareous, compact clay containing some fine gravel and sand.
VARIATIONS: The proportion of Riesel soil ranges from about 40 to 60 percent of each delineated area.

Location and Extent: Scattered areas on the margins of high old stream terraces in eastern parts of the county, mainly in the vicinities of Ross, Tokio, Elm Mott, Axtell, and Riesel.
Relief and Drainage: Gently sloping; runoff is medium and internal drainage is slow.
Erosion: Erodes slightly to moderately if cultivated; 40 percent has no appreciable erosion; 60 percent is moderately eroded and has scattered gullies and rills.
Parent Material: Old gravelly alluvium intermixed with locally reworked calcareous marine clays.
Native Vegetation: Mostly grass but includes scattered elm and post oak.
Utilization: Principally for cotton, corn, and sorghums; pasture and pastured woodland.
Land Class and Agronomic Group: Second-class; group 7.

Riesel-Irving gravelly clay loams, 4 to 8 percent slopes (RD).—This sloping complex consists of small intermingled areas of gravelly clay loams of the Riesel and Irving series. Small areas of Houston clay occur in places. The complex is in the same general localities as Riesel-Irving gravelly clay loams, 1 to 4 percent slopes, and it occupies transitional areas between sandy timbered upland and the Blackland Prairie. It is suitable as cropland in limited degree but is rather difficult to work and erodes severely unless carefully protected. As a whole, it is somewhat better suited to pasture than to field crops.

About a third of the complex is in cultivation, and the rest is in pasture and pastured woodland. About half is moderately to moderately severely eroded and has a loamy surface soil averaging about half as thick as in the uneroded areas. On the rest, which is mostly native pasture, no or slight erosion has occurred. The principal crops are cotton, corn, and grain sorghums; yields are low to moderate. The best use for the more sloping eroded areas is for pasture. This is a Third-class soil and is in agronomic group 11.

RIVERWASH

Riverwash (RE) consists of unstable areas of river sands and silts that are subject to frequent flooding and movement and have little or no vegetation. The areas are shown on the map as they existed in the summer of 1942. At that time they were valueless for agriculture. They lie next to the channel of the Brazos River about 6 miles south of Waco. Here, rapid changes in the river channel occur. The channel shifted almost one-half mile in one place during 1942. Hence, the areas of riverwash are temporary. They gradually build up, however, and become covered with vegetation, mainly cottonwood and willow trees and bermudagrass. After a few years, when trees and grass become established, this land becomes fair for pasture. This nonarable land is in agronomic group 23.

ROUGH BROKEN LAND

Rough broken land (Rf) comprises broken and rough areas with little soil or vegetation. Most areas are outcrops of yellow calcareous clays similar to those that underlie the Houston and Sumter soils. However, outcrops of chalky marls, such as underlie the Austin soils, and of sandy clays, such as underlie the Axtell soils, are also included. Some of the larger areas of this land type are just south of Lake Waco at the base of the chalk escarpments; other fairly large areas are east of Gholson School along Aquilla Creek. Small areas occur in several other places in the eastern parts of the county.

Rough broken land, which has slopes ranging from about 20 to 40 percent, is extremely poor for agriculture or forestry. A small part is cultivated; the rest is used for pasture, or is in scrub woodland of cedar, elm, and oak. About 97 percent of Rough broken land has no accelerated erosion; and 3 percent, which is mainly land that has been cultivated, is severely eroded and gullied and is valueless for agriculture. None of this land type is suitable for cultivation; its best use is for growing cedar for fence posts and for incidental grazing where feasible. It is nonarable and is in agronomic group 23.

ROUGH STONY LAND, BRACKETT SOIL MATERIAL

Rough stony land, Brackett soil material (Rg) occupies steep rocky limestone areas where slopes range from about 20 to 40 percent. Although bare ledges of bedrock outcrop in places, this land type consists mainly of a mantle of weathered broken limestone intermixed with gray calcareous clay. The layer of soil and loose stones is commonly less than 5 inches deep, but crevices filled with soil extend downward several feet into the limestone bedrock. This land supports a mixture of grass, shrubs, and trees (pl. 5). Texas red oak, shinnery white oak, cedar, redbud, and ill-scented sumac are the principal woody species. Hairy grama, side-oat grama, Texas grama, and little bluestem are some of the principal grasses.

The main areas lie along the major streams in the northwestern part of the county. No single body is larger than 1,000 acres. All is used for pastures; about 25 percent is grassland, and about 75 percent is woodland that affords some grass and browse. The carrying capacity is probably only about 1 cow, or the equivalent in other livestock, to 35 acres. Because much of the forage is browse, pastures are somewhat better for goats and sheep than for cattle. This land type is classed as nonarable and is in agronomic group 23.

SAN SABA SERIES

The San Saba series consists of very dark-gray to black crumbly clays underlain by limestone. The soils are slowly drained and are the darkest of those on the Grand Prairie.

San Saba clay, 0 to 2 percent slopes (Sa).—This soil is deep crumbly blackland of the Grand Prairie. It is similar to the Houston Black clays in most respects but differs in being underlain by limestone instead of by calcareous clay or chalk. The soil is deep, fertile, and crumbly and is cultivated without unusual difficulty. It is largely in cultivation to common field crops and is highly esteemed by farmers.

Representative profile:

0 to 18 inches, very dark-gray calcareous crumbly heavy clay; granular.
18 to 40 inches, very dark-gray calcareous heavy clay; somewhat more compact and less crumbly than above layer.
40 to 50 inches, dark olive-gray calcareous heavy clay; compact and very slowly permeable.
50 inches +, limestone; partly weathered in the upper part and interbedded with seams of marl.
VARIATIONS: In about one-third of the area, the soil material is neutral and noncalcareous to a depth of 20 to 30 inches; depth to limestone is everywhere more than 24 inches and mostly more than 36 inches; parts of the area 2 miles east of the northwest corner of the county (just north of the Middle Bosque Canyon) are a crusty dark-gray soil that is like Burleson clay in profile but underlain by limestone.

Location: On the Grand Prairie; the main areas are east and south of McGregor.
Relief and Drainage: Level to gently sloping; both runoff and internal drainage are slow to almost none.
Erosion: Only very slightly susceptible.
Parent Material: Limestone with some interbedded marl.
Native Vegetation: Mostly prairie grasses; some trees near areas of stony soils.
Utilization: Nearly three-fourths is cultivated, mainly to cotton, corn, and sorghums; considerable acreages of oats are grown but, so far as feasible, the farmers concentrate their small grains on the associated areas of shallower soils; urban areas and farmsteads; pasture.
Land Class and Agronomic Group: First class; group 4.

San Saba clay, shallow variant, 0 to 1 percent slopes (SB).—This soil resembles San Saba clay except that depth to limestone is less than about 24 inches. Most of the soil, except a few areas on seepy places, is suited to crops but is somewhat less productive than San Saba clay, 0 to 2 percent slopes.

Representative profile:

0 to 15 inches, very dark-gray to black calcareous heavy clay; crumbly and granular.
15 to 21 inches, very dark grayish-brown calcareous heavy clay.
21 inches +, hard limestone, partly weathered in the upper part.
VARIATIONS: In small spots a few large fragments of hard limestone occur in the soil layers, but they are readily removed from fields; depth of soil over limestone ranges from about 12 to 24 inches.

Location: A few rather small areas in the vicinity of Crawford; most areas are in shallow valleys.
Relief and Drainage: Nearly level; concave slopes; runoff and internal drainage are slow; some areas affected by high ground water during wet seasons.
Erosion: Not susceptible.
Parent Material: Hard limestone.
Native Vegetation: Mostly grass.
Utilization: About half is cropland used for cotton, corn, sorghums, and oats; the rest in native pasture, about half of which has a fairly thick cover of elm and live oak.
Land Class and Agronomic Group: Second-class; group 9.

San Saba-Crawford stony clays, 1 to 2 percent slopes (Sc).—This complex occurs northwest of Crawford on gently sloping to level areas that follow the outcrops of the ledges of hard limestone. It differs from Tarrant stony clay in having greater depth of soil over bedrock; hence, it is better land for grazing. Stones are so numerous that tillage is impractical. The complex consists of small intermingled areas of nearly black and dark reddish-brown very stony heavy clays from 10 to 30 inches deep over bedrock of hard limestone. The black soil, which is either calcareous or noncalcareous, is San Saba stony clay; the noncalcareous dark reddish-brown soil is Crawford stony clay. In addition, small areas of limy brown Tarrant stony clay are included in the complex.

All of this complex except 100 acres is in native pasture that consists of a mixture of grassy glades and thickets of brush (pl. 6, *A* and *B*). The few small cultivated fields are used mainly for growing corn or grain sorghum. The principal woody vegetation is the shinnery white oak (*Quercus breviloba*); other common species are ill-scented sumac, Texas red oak, live oak, and a few post oaks. The grassy glades between clumps of brush and trees have a thick turf of buffalograss that spreads rapidly throughout the entire areas when the brush and trees are removed. The carrying capacity of this complex, where brush has been removed, probably is about 1 cow to 6 acres. The complex is classed as nonarable and is in agronomic group 21.

SAWYER SERIES

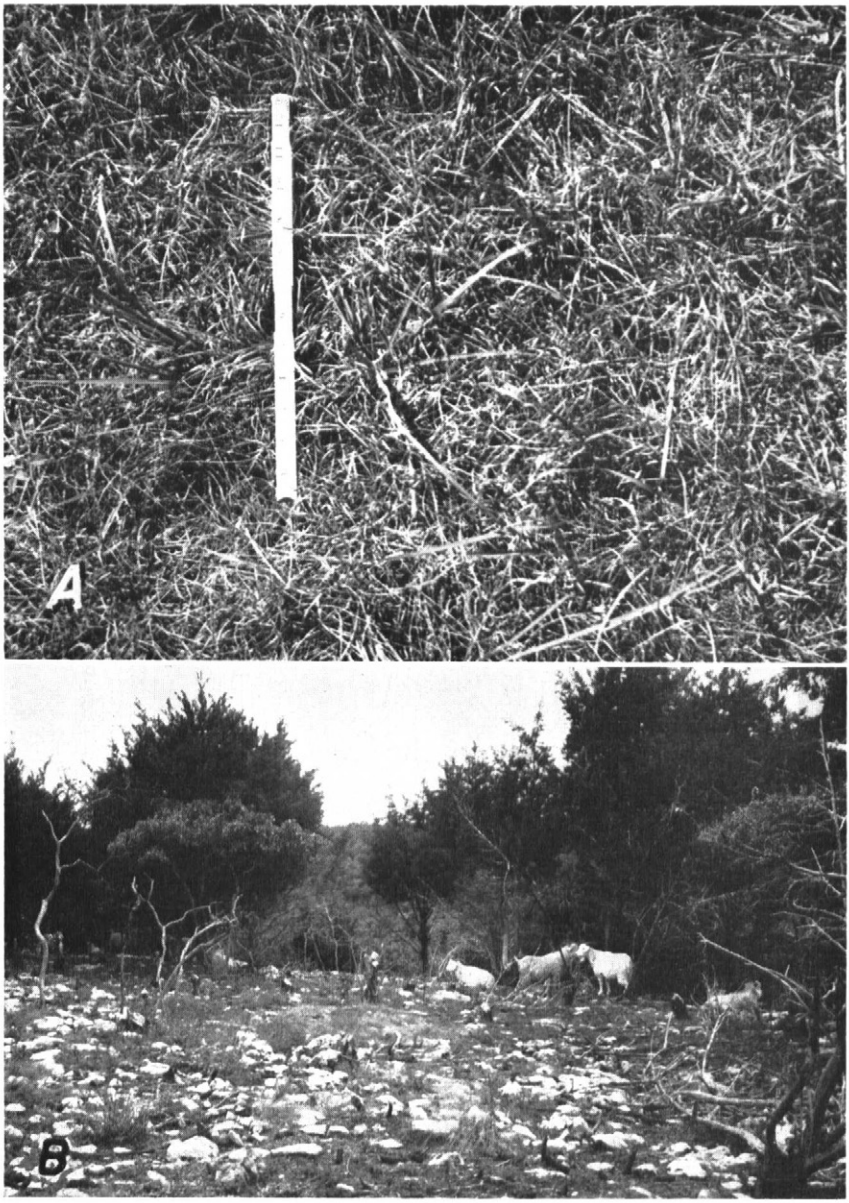
The Sawyer series is of light-colored timbered sandy soils having subsoils of sandy clay, yellowish in the upper part but mottled below 2 feet. It differs from the Axtell series in having thicker sandy surface layers and less impervious subsoils. The Sawyer soils are extensive in the timbered part of eastern Texas, where they are slightly more acid and have somewhat less sandy parent materials than in McLennan County, which is about the western limit of the series range.

Sawyer fine sandy loam, 0 to 1 percent slopes (Sd).—This soil is a fine sandy loam with a slowly to very slowly permeable subsoil of moderately heavy sandy clay. It is easily worked and productive for a wide variety of crops when given good management. The soil is low in original supply of plant nutrients and organic matter; hence, when it is continuously cropped without measures to replenish fertility, yields soon become very low. It is very responsive to manuring, and yields vary widely with management.

Representative profile (a forested area 4 miles north of Waco):

0 to 3 inches, grayish-brown light fine sandy loam; friable; neutral.
3 to 15 inches, very pale-brown light fine sandy loam containing a few fine pebbles; slightly acid.
15 to 17 inches, brownish-yellow sandy clay loam; moderately acid.
17 to 25 inches, brownish-yellow heavy sandy clay mottled with reddish brown and light gray; slowly permeable; moderately acid.
25 to 40 inches, yellow plastic sandy clay mottled with light gray; slightly acid.
40 to 60 inches +, parent material of pale-yellow and light-gray sticky sandy clay loam.

Landscape in hilly area in the Grand Prairie along Bluff Creek. In background, Rough stony land, Brackett soil material, showing characteristic growth of cedar (juniper); in the immediate foreground, Catalpa clay and native pecan tree.

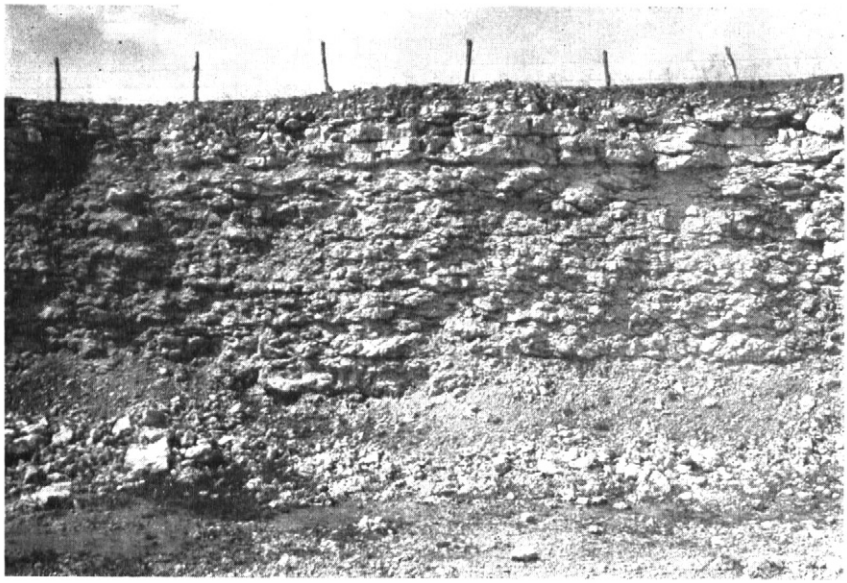


A, Closeup of dense turf of buffalograss on San Saba-Crawford stony clays. The rule in the photograph is 12 inches long.

B, Closely grazed pasture on San Saba-Crawford stony clays. Although this soil is stony and appears very shallow, depth to bedrock is 2 feet or more and buffalograss affords excellent pasturage. Compare the size and abundance of exposed stone with that of Tarrant stony clay (pl. 7, *B*).

A, Grain sorghum at maturity on Tarrant stony clay. This very shallow soil is unsuited to crops and should be used as native pasture.

B, Vegetation on Tarrant stony clay in a closely grazed area adjacent to limestone bluffs.



Profile of Tarrant stony clay.

VARIATIONS: Where cultivated the surface soil is pale brown to 7 inches; the unmottled yellowish horizon, which is at depths of 15 to 17 inches in the profile given, ranges up to 5 inches in thickness in some places; depth to the sandy clay subsoil ranges from about 15 to 24 inches.

Location: Old stream terraces; largest areas are near Asa.
Relief and Drainage: Gently sloping with gradients mostly less than 2 percent and nowhere more than 4 percent; surface drainage is medium; internal drainage is slow.
Erosion: Only slightly susceptible.
Parent Material: Ancient alluvium of the Brazos River; presumably calcareous at great depths.
Native Vegetation: Oak forest.
Utilization: Mostly in cultivation; principal crops are peanuts, corn, cotton, cowpeas, peaches, sweetpotatoes, and garden vegetables; pasture and woodland; urban areas and farmsteads.
Land Class and Agronomic Group: Third-class; group 13.

STIDHAM SERIES

The Stidham series consists of light-colored sandy soils having permeable subsoils of yellowish friable sandy clay loam within 3 feet of the surface. It developed in this county under scrub oak forest in ancient alluvium of the Brazos River. It is closely related to the Bowie series of more humid parts of the Gulf Coastal Plain but is slightly less acid and contains slightly more weatherable minerals. It differs from the Milam series in having yellowish instead of reddish subsoils and from the Eufaula in having a more clayey subsoil within 3 feet of the surface.

Stidham loamy fine sand, 0 to 2 percent slopes (Se).—This is a deep sandy soil with a permeable subsoil of yellowish sandy clay. It is slightly more fertile, not quite so loose and susceptible to soil blowing and better suited as cropland than Eufaula fine sand, 0 to 2 percent slopes.

Representative profile (a forested area near Gholson School):

0 to 4 inches, pale-brown loamy fine sand; neutral.
4 to 27 inches, very pale-brown loamy fine sand; slightly acid.
27 to 40 inches, yellow friable sandy clays; slightly mottled with gray in the upper part and reddish spots in the lower part; moderately acid.
40 to 60 inches +, parent material of yellow noncalcareous sand with seams of reddish-yellow sandy loam.
VARIATIONS: Depth to the sandy clay subsoil ranges from 24 to 36 inches.

Location: Areas occur on stream terraces near Gholson School and Robinson.
Relief and Drainage: Gently undulating; runoff is slow and internal drainage is medium.
Erosion: Not susceptible to water erosion; some soil blowing when surface is bare of vegetation.
Parent Material: Old sandy alluvium of the Brazos River.
Native Vegetation: Scrub forest of post oak and blackjack oak.
Utilization: Mainly in cultivation; principal crops are peanuts, corn, cowpeas, and some cotton and vegetables; pasture and woodland.
Land Class and Agronomic Group: Fourth-class; group 17.

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SUMTER SERIES

The Sumter series is yellowish-brown to brownish-yellow or olive-brown calcareous clay that grades within 5 to 20 inches of the surface into raw parent material of calcareous marine clay or marl. It is less dark and shallower to raw substratum than the Houston clay soils.

Sumter clay, 8 to 20 percent slopes (SF).—Most areas of this soil are on severely eroded fields that were Houston clays before cultivation; some are steeply sloping and have always been Sumter. The soil is generally unfit for crops. It affords much good pasture wherever the native grasses have not been destroyed. Grasses are reestablished with difficulty in eroded fields. Cropland consists of small areas in association with surrounding less sloping and less eroded soils.

Representative profile:

0 to 3 inches, yellowish-brown calcareous heavy clay; crumbly and granular.
3 to 15 inches, light yellowish-brown or olive-yellow calcareous heavy clay.
15 to 50 inches +, parent material of pale-olive and yellow raw shaly marl or highly calcareous clay; nearly impervious.

VARIATIONS: Color of surface soil ranges from olive brown to dark yellowish brown, and the depth to raw parent material from 12 to 30 inches. The areas near Moody, which are associated with Austin soils, are of light yellowish-brown friable silty clay or light clay, underlain by friable marl, and comprise about one-fifth of the total area in the county; some areas have outcropping ledges of flagstone, which are indicated on the soil map by symbol. Another inclusion consists of severely eroded strongly sloping areas of brownish-yellow alluvial marl underlain at depths of 5 to 15 feet by beds of limestone gravel; these areas were strongly sloping Lewisville soils before they were severely eroded.

Location: Eroded hills in parts of the Blackland Prairie.

Relief and Drainage: About three-fourths is strongly sloping with gradients of 8 to 20 percent, and the rest moderately sloping with gradients of 4 to 8 percent. Runoff is very rapid; internal drainage is almost none in all areas except those underlain by friable marl. Areas over marl have medium internal drainage.

Erosion: Very susceptible; the 15 percent that has native grass cover is inappreciably affected by accelerated erosion; the other 85 percent consists of severly eroded areas formerly of Houston clay; gullies are numerous.

Parent Material: Mostly compact shaly marl of marine origin; calcareous clayey alluvium in a few areas associated with Lewisville soils.

Native Vegetation: Medium-height prairie grasses.

Utilization: More than 50 percent in cultivation; most of the rest in pasture (mainly abandoned fields); urban areas and farmsteads.

Land Class and Agronomic Group: Nonarable; group 21.

TARRANT SERIES

The Tarrant series comprises dark-colored very shallow soils on limestone in the Grand Prairie. It is the very shallow associate of the Denton series. Although rather closely related to the Brackett,

these soils are darker and are much better grazing lands. The Tarrant is one of the most extensive series of the Grand Prairie section of McLennan County.

Tarrant stony clay, 1 to 8 percent slopes (TB).—This dark stony soil is too shallow for crops but is valuable for pasture (pl. 7, *A* and *B*). It is one of the principal soils of the Grand Prairie and covers large areas, which are in cattle ranches, and many small areas scattered through tracts of deeper soils where general farming is practiced.

Representative profile (pl. 8):

0 to 5 inches, dark grayish-brown calcareous granular clay containing numerous small and large fragments of limestone.
5 to 12 inches, partly weathered limestone, the crevices filled with brown clay that makes up some 10 percent of the volume.
12 inches +, bedrock of solid limestone.
VARIATIONS: The color of the soil material varies from grayish brown to very dark grayish brown; the depth of soil over partly weathered limestone ranges from 3 to 7 inches.

Location: Large and small areas in the Grand Prairie.
Relief and Drainage: Gently to moderately sloping; about two-thirds of the area has gradients between 1 and 4 percent, and one-third has gradients between 4 and 8 percent; runoff is medium to rapid; internal drainage is medium.
Erosion: Slightly susceptible under native grass, the proper use for this very shallow soil.
Parent Material: Limestone.
Native vegetation: Grass with scattered live oak trees; some areas near canyons have considerable cedar and brush; the original grass cover was apparently mainly little bluestem; it is now mainly such short grasses, as Texas grama, hairy grama, and buffalograss.
Utilization: Mainly pasture, 3,000 acres of which has a fairly thick cedar and brush cover; about 20 percent cultivated; idle cropland, urban areas, and farmsteads.
Land Class and Agronomic Group: Nonarable; group 21.

Tarrant-Brackett stony clays, 8 to 20 percent slopes (TA).—This complex consists of strongly rolling to hilly areas of stony very shallow soils on limestone. The principal soil is Tarrant stony clay, but associated with it are many small areas of Brackett stony clay and Rough stony land. Brackett stony clay consists of a few inches of gray or light brownish-gray calcareous stony clay underlain by limestone.

The areas of Tarrant-Brackett stony clays, 8 to 20 percent slopes, differ from those classed as Tarrant stony clay in being hilly and in affording somewhat less grazing. The principal areas of this complex are along the North Bosque River west of China Spring.

This complex is unsuitable for crops. Nearly all is in native pasture, of which 500 acres has a thick cover of shinnery white oak, cedar, Texas red oak, and sumac. The pastures are grazed mainly by cattle and have a year-round carrying capacity of about 18 acres to the cow. The grasses are mainly Texas grama, black grama, three-awn, and little bluestem, together with some buffalograss in local spots of deeper soil. Even under a native vegetation, this complex erodes rapidly. If the cover is destroyed, the thin surface soil is quickly

washed off the underlying bedrock. This is a nonarable soil complex and is in agronomic group 21.

TRAVIS SERIES

The Travis series consists of light-colored acid forested soils with red moderately permeable sandy clay to clay subsoils. These soils occur on dissected remnants of old stream terraces and differ from the associated Milam soils in having subsoils of sandy clay to clay rather than sandy clay loam.

Travis fine sandy loam, 1 to 4 percent slopes (Tc).—This soil occurs on inextensive areas in the sandy timbered uplands of the county. It is naturally of rather low fertility but responds readily to soil management. It is particularly suitable for truck crops, fruits, and peanuts.

Representative profile (a forested area):

0 to 3 inches, grayish-brown fine sandy loam; neutral.
3 to 15 inches, very pale-brown light fine sandy loam; slightly acid.
15 to 45 inches, red sandy clay; slightly acid; stiff but crumbly and permeable.
45 to 60 inches +, bed of fine waterworn gravel, mostly of chert; noncalcareous.
VARIATIONS: Color of the surface soil ranges from grayish brown in undisturbed areas to brown or light brown where cultivated; the deep substratum, which is not necessarily of the same material as that from which the soil was formed, may be chalk, gravel, or sandy clay. Some fine pebbles are present throughout the soil in many places.

Location: Small well-drained areas on old high stream terraces in the eastern parts of the county.
Relief and Drainage: Gently sloping; both runoff and internal drainage are medium.
Erosion: Slightly to moderately susceptible.
Parent Material: Old alluvium of the Brazos River containing stratified clay, sand, and gravel; mostly calcareous below depths of 6 to 10 feet.
Native Vegetation: Oak forest.
Utilization: Cultivated crops, mainly peanuts, truck, fruit, cotton, and corn; pasture and woodland.
Land Class and Agronomic Group: Third-class; group 13.

Travis fine sandy loam, 4 to 8 percent slopes (Td).—This soil is like Travis fine sandy loam, 1 to 4 percent slopes, in profile except that its surface soil is somewhat thinner because of erosion. It erodes very rapidly if cultivated, and in many areas has less than 5 inches of fine sandy loam surface soil over the clayey subsoil. The bodies of this soil are small and mainly in the Chalk Bluff community about 6 miles north of Waco. The soil is associated with Travis fine sandy loam, 1 to 4 percent slopes, and is used in about the same way. Most areas are suited to crops in limited degree, but intensive management for erosion control and some fertilization are required for good yields. About one-third is not appreciably modified by erosion, another third is moderately eroded, and the remaining one-third is severely eroded. One of the best uses for this soil, if it is cultivated, is for orchards. This is a Fourth-class soil and is in agronomic group 19.

TRINITY SERIES

The Trinity series consists of very dark calcareous clayey alluvial soils. These soils are of recent stream sediments washed mostly from areas of Blackland Prairie. They are black, dark gray, or very dark grayish brown; have very slow internal drainage; and are subject to periodic flooding.

Trinity clay, 0 to 1 percent slopes (Te).—This is a dark-colored deep fertile clayey soil of the first bottoms along streams that drain areas of deep crumbly blackland. The soil is very heavy but crumbly and has excellent tilth, but at times is wet for extended periods. All areas are flooded by waters from adjacent streams, some so frequently that they are best used for pasture. In most areas, however, the flood hazard does not prevent successful production of crops but makes it rather difficult and expensive.

Representative profile:

0 to 50 inches +, dark-gray calcareous heavy clay; very plastic and sticky when wet; crumbly when plowed; slowly permeable.

VARIATIONS: The color varies from dark gray or black to very dark grayish brown, being brownest in bottoms of streams that drain areas of Houston clays and Sumter clay.

Location: The principal soil of the flood plains of streams in the Blackland Prairie; large areas are along Tehuacana Creek.

Relief and Drainage: Practically level; drainage is very slow both from the surface and internally.

Erosion: Not susceptible; some scouring by floodwaters occurs locally.

Parent Material: Recent stream sediments from areas of deep crumbly blackland.

Native Vegetation: Forest, mainly elm and hackberry.

Utilization: Cultivated crops (cotton and corn); pasture.

Land Class and Agronomic Group: Third-class; group 14.

VANOSS SERIES

The Vanoss series consists of grayish-brown soils of medium or sandy textures that have permeable moderately fine textured yellowish-brown to brown subsoils. They are associated with Bastrop and Brewer soils on low terraces along the Brazos River. The Vanoss soils are fertile, easily worked, well drained, and largely in cultivation.

Vanoss fine sandy loam, 0 to 1 percent slopes (Va).—This is a grayish-brown soil that occurs in some of the sandier parts of low terraces along the Brazos River. It is moderately fertile, and productive for a wide variety of field and special crops. Since it contains more sand than Vanoss silt loam, its fertility is more rapidly depleted under the usual management.

Representative profile (3 miles east of Waco):

0 to 15 inches, grayish-brown mellow fine sandy loam; neutral; weakly granular.

15 to 30 inches, yellowish-brown noncalcareous friable sandy clay loam; freely permeable.

30 to 45 inches, light yellowish-brown or brownish-yellow friable sandy clay loam containing brown spots; noncalcareous.

45 to 60 inches, light yellowish-brown noncalcareous sandy clay loam.

60 to 75 inches, light yellowish-brown noncalcareous fine sandy loam.
75 to 100 inches +, light yellowish-brown or yellow calcareous fine sandy loam.
VARIATIONS: The depth of the sandy layer over the heavier subsoil ranges from 12 to 30 inches; a few small areas of other soils are included, mainly depressed areas of gray sandy loam with subsoils of mottled yellow and gray sandy clay.

Location: Associated with Bastrop fine sandy loam and some Stidham loamy fine sand on low terraces along the Brazos River; the largest areas are near East Waco and Rock Creek.
Relief and Drainage: Nearly level; runoff is slow; internal drainage is medium and very favorable for crops.
Erosion: Not susceptible.
Parent Material: Old sandy alluvial sediments of the Brazos River.
Native Vegetation: Mostly forest.
Utilization: In cultivation, mainly for cotton, corn, and peanuts; urban areas.
Land Class and Agronomic Group: First-class; group 6.

Vanoss silt loam, 0 to 1 percent slopes (VB).—This is a dark grayish-brown fertile soil in nearly level but well-drained areas on low benches along the Brazos River. The soil is productive for a wide variety of crops and well liked by farmers.

Representative profile (3 miles east of Waco):

0 to 10 inches, dark grayish-brown noncalcareous silt loam; friable; neutral; granular.
10 to 18 inches, brown noncalcareous friable silty clay loam; granular.
18 to 35 inches, yellowish-brown noncalcareous friable silty clay loam; freely permeable.
35 to 50 inches, brownish-yellow noncalcareous friable silty clay loam.
50 to 70 inches +, light yellowish-brown calcareous friable silt loam.
VARIATIONS: Color of the surface soil ranges from dark brown to dark grayish brown or grayish brown; thickness ranges from 8 to 14 inches.

Location and Extent: Occurs on low terraces of the Brazos River in association with more slowly drained Brewer clay loam, and more rapidly drained Bastrop soils; large areas are just southeast of Waco.
Relief and Drainage: Nearly level; runoff is slow; drainage is free internally and very favorable for crops.
Erosion: Not susceptible to any appreciable degree.
Parent Material: Alluvial sediments of the Brazos River.
Native Vegetation: Mostly grass with scattered trees.
Utilization: Mainly in cultivation; cropland used for general farming and locally for truck farming; the principal field crops are cotton, corn, and sorghums; urban areas.
Land Class and Agronomic Group: First-class; group 6.

WILSON SERIES

The Wilson series consists of gray to dark-gray noncalcareous crusty soils with subsoils of dark-gray tough compact clay. They are similar to the Irving soils of stream terraces but occur on old upland underlain by weakly to moderately calcareous marine clays. The Wilson soils are very extensive in the eastern part of the Blackland Prairie and are commonly known as tight land or mixed land. Al-

though they have less favorable tilth and are slightly more droughty than the crumbly blackland soils, such as Houston Black clay, the Wilson soils are moderately productive, especially for the more drought-resistant crops, and are well esteemed by farmers.

Wilson clay loam, 0 to 1 percent slopes (Wc).—This is a dark-gray crusty clay loam with a claypan subsoil of dark-gray tough clay. It occupies large areas of level or nearly level upland in the eastern part of the county. The soil is free from erosion but occasionally has inadequate drainage during very wet seasons. A large percentage is cultivated mainly for cotton.

Representative profile.

0 to 10 inches, gray to dark-gray noncalcareous clay loam; slightly acid; weakly granular; very hard when dry; the surface crusts on drying without tillage.
10 to 35 inches, dark-gray noncalcareous compact heavy clay; coarse blocky; extremely hard and tough when dry; a claypan.
35 to 50 inches, gray calcareous tough clay.
50 to 70 inches, light brownish-gray calcareous tough clay.
70 to 100 inches +, parent material of yellow and light-gray calcareous compact clay or sandy clay.
VARIATIONS: Thickness of the clay loam surface soil ranges from 3 to 15 inches; 120 acres of Wilson silt loam (which is similar save for silt loam surface soil) is included.

Location: All in the eastern corner of the county.
Relief and Drainage: Nearly level upland; both runoff and internal drainage are very slow.
Erosion: Not susceptible.
Parent Material: Weakly to moderately calcareous compact clay or sandy clay of marine origin.
Native vegetation: Tall grass.
Utilization: All in cultivation; used for cotton, corn, sorghums, and oats.
Land Use and Agronomic Group: Second-class; group 8.

Wilson clay loam, 1 to 3 percent slopes (Wb).—This soil has about the same profile characteristics, use, and productivity, as Wilson clay loam, 0 to 1 percent slopes, but differs in topography. Because of its gently sloping surface, it has better drainage but some susceptibility to erosion where cultivated.

Representative profile:

0 to 10 inches, dark-gray noncalcareous clay loam; weakly granular; friable when moist, very hard when dry; surface crusts on drying without tillage; slightly acid.
10 to 36 inches, dark-gray noncalcareous heavy clay of coarse blocky breakage; very slowly permeable; very hard when dry; slightly acid in the upper part; a claypan.
36 to 60 inches, gray to light brownish-gray calcareous very compact clay containing a few concretions of carbonate of lime.
60 to 80 inches +, parent material of yellow and light-gray calcareous compact clay.
VARIATIONS: Thickness of clay loam surface soil ranges from 3 to 12 inches in both undisturbed and cultivated areas.

Location and Extent: Occupies large continuous areas of upland in the eastern part of the county; associated soils of more sloping areas are of Wilson-Houston complex; associated level areas are of Wilson clay loam, 0 to 1 percent slopes.

Relief and Drainage: Gently undulating; convex surfaces; runoff slow to medium, and internal drainage very slow.
Erosion: Slightly to moderately susceptible under clean-tilled crops; slight erosion prevails in most areas; in about one-fourth of the extent erosion has thinned the clay-loam layer by removal of 2 to 5 inches. No areas are severely eroded.
Parent Material: Weakly to moderately calcareous compact marine clay or sandy clay.
Native Vegetation: Tall grass.
Utilization: Mainly in cultivation; principal crop is cotton, followed in acreage by corn, sorghums, and oats; pasture (900 acres has a fairly thick cover of elm, hackberry, and mesquite trees); urban areas and farmsteads.
Land Class and Agronomic Group: Second-class; group 7.

Wilson-Houston complex, 3 to 8 percent slopes (We).—This sloping complex is in areas of prairie that are occupied by a mixture of Wilson clay loam and Houston clay. The component soils occur in alternating strips, 10 to 20 feet wide, that run up and down the slopes. Their distribution is related to the microrelief of the surface before disturbance by cultivation.

This complex is suitable for crops but requires careful management to prevent erosion. The yields vary widely with management and the severity of erosion. Most fields that produced good yields when first cropped now produce low yields. Several fields that were rather severely eroded in past years have been well terraced and have had Hubam clover plowed under every few years and now produce good crops. Many areas can well be used for permanent pasture.

Representative profile of Wilson clay loam, 3 to 8 percent slopes (in native grass):

0 to 7 inches, dark grayish-brown noncalcareous clay loam; moderately granular; neutral.
7 to 18 inches, dark-gray noncalcareous heavy clay; moderately compact but weakly granular.
18 to 30 inches, light olive-brown calcareous compact clay; slowly pervious.
30 to 60 inches +, pale-olive, highly calcareous, compact shaly clay.

Representative profile of Houston clay:

(See profile of Houston clay, 4 to 8 percent slopes.)
VARIATIONS: Tillage and erosion have modified the areas considerably; the two soils have been mixed so that the plow layer is now calcareous in nearly all places; on margins of stream terraces a few small areas that are a mixture of sloping areas of Lewisville, Irving, and Norge soils are included; in the more severely eroded areas there are some small spots of Sumter clay.

Location: Blackland Prairie on slopes that adjoin smoother areas of Wilson clay loam and Irving clay loam.
Relief and Drainage: Moderately sloping; runoff is rapid; internal drainage is very slow.
Erosion: Very susceptible if cultivated; 32 percent, the portion remaining in native grass, is not appreciably affected by erosion or is slightly eroded; 51 percent is moderately eroded (surface layer of clay loam thinned about one-half), that is, gullies and rills are numerous, and productivity has been lowered 25 to 50 percent; 17 percent is severely eroded and is very poorly suited to crops.

Parent Material: Calcareous compact clays, mostly marine but partly old alluvium.
Native Vegetation: Tall prairie grasses.
Utilization: More than half in cultivation; principal field crops are cotton, corn, and sorghums; pasture (800 acres has a fairly thick cover of elm, oak, and mesquite trees).
Land Class and Agronomic Group: Fourth-class; group 20.

Wilson-Houston complex, 8 to 15 percent slopes (WF).—This strongly sloping complex occupies the more sloping areas but is otherwise like the Wilson-Houston complex, 3 to 8 percent slopes. Gradients range from about 6 to 20 percent but are dominantly 8 to 15 percent. Most areas are crossed by numerous gullies. This complex is poorly suited to crops and best used for permanent grass. It is very susceptible to erosion if used for crops, and only about 20 percent is cultivated. The areas in native grass, about 70 percent of the total, are not appreciably affected by erosion; the 30 percent that has been cultivated is severely eroded and of low value for pasture.

The native prairie pastures on this complex have a carrying capacity of 1 cow to about 7 acres where well managed. About 200 acres is in woodland pasture. The complex is nonarable and in agronomic group 21.

YAHOLA SERIES

The Yahola series is composed of reddish calcareous alluvial soils with sandy subsoils. They consist of little modified recent sediments along rivers such as the Brazos that drain the Red Plains of western Oklahoma and Texas. In McLennan County the Yahola soils occur in the first bottoms of the Brazos River. Their sandy subsoils distinguish them from the associated Norwood soils, and their lower situation and absence of darkening in the surface soil distinguish them from the Brazos soils.

Yahola silt loam, 0 to 1 percent slopes (YA).—This is a slightly reddish limy soil that consists of recent sediments of stratified silt and sand deposited by floodwaters. The soil is moderately fertile and well drained but subject to occasional overflow. Because of its sandy subsoil, it is somewhat less productive than the Norwood soils. Most areas are in cultivation and are used mainly for cotton and corn. The areas not cultivated are mostly low bottoms near the Brazos River.

Representative profile:

0 to 20 inches, reddish-brown calcareous silt loam; very friable.
20 to 50 inches +, light reddish-brown calcareous very fine sandy loam stratified with lenses of fine sand.
VARIATIONS: Color of the surface soil ranges from brown to reddish brown; depth to sandy material ranges from about 10 to 30 inches; some small areas with very fine sandy loam or clay loam surface soil are included.

Location: Flood plain of the Brazos River.
Relief and Drainage: Nearly level; runoff is medium; internal drainage is rapid; most areas are flooded every few years; some low areas are frequently flooded or are destroyed by changes in the river channel.

Erosion: Not susceptible.
Parent Material: Stratified alluvial silts and sands from the Brazos River.
Native Vegetation: Forest.
Utilization: More than half is cropland used mainly for cotton and corn; pasture; pastured native forest.
Land Class and Agronomic Group: Second-class; group 10.

Yahola very fine sandy loam, 0 to 1 percent slopes (Yb).—This soil occurs on moderately sandy first bottoms of the Brazos River. It is somewhat too sandy for highest fertility but produces moderate yields of cotton, corn, and other crops.

Representative profile:

0 to 20 inches, reddish-brown, calcareous, light very fine sandy loam.
20 to 50 inches +, light reddish-brown very fine sandy loam stratified with fine sand.
VARIATIONS: Small bodies of Yahola loamy very fine sand included.

Location: First bottoms of the Brazos River.
Relief and Drainage: Nearly level flood plain; runoff is medium and internal drainage is rapid to very rapid; floods occur every few years.
Erosion: Nonsusceptible to water erosion; some soil blowing occurs when surface is bare of vegetation.
Parent Material: Recent sandy sediments of the Brazos River.
Native Vegetation: Forest.
Utilization: Mostly cropland used for corn and cotton; pasture, 100 acres of which is woodland; urban areas and farmsteads.
Land Class and Agronomic Group: Fourth-class; group 18.

USE AND MANAGEMENT[4] OF SOILS

CURRENT MANAGEMENT AND SOIL FERTILITY

The soil management now current in McLennan County consists essentially of tillage for seedbed preparation, the control of weeds, and some alternation of crops. On some farms, contour cultivation, terracing, and growing of legumes for green manure are used for soil improvement and erosion control. The principal crops are clean tilled and include no legumes. Almost no manure is available for application to the fields, since few livestock are kept on most farms. Commercial fertilizers are used on all legumes and small grains. With the exception of contour cultivation, terracing, and use of legumes for green manure (which are recent developments), this type of soil management has prevailed in nearly all fields since they were first placed in cultivation. Most fields have been cropped for 40 to 60 years. The management does not maintain soil fertility; the prevailing crop yields are materially lower than those obtained when the land was new.

The amount and rate of decrease in productivity vary widely among soils. Most of the bottom lands were very fertile to begin with, and

[4] This section prepared by Harvey Oakes, soil scientist, Soil Conservation Service.

they receive some new fertility when fresh soil material is deposited during floods. Consequently, crop yields are only slightly lower than they were in early times, and this reduction is in part due to factors other than soil fertility. Cotton yields are lower principally because of increased damage by insects. Corn and other crops yield slightly less, partly because of a reduction in soil fertility.

The heavy bottom lands are examples of areas having only slightly reduced fertility. The sandy uplands and strongly sloping prairie soils represent the other extreme; these soils have been depleted of the original small to large stores of plant nutrients by exhaustive cropping and rapid erosion. Commonly, the more sloping or sandier areas are farmed until the usual cotton yields fall below about 100 pounds of lint to the acre and then are retired from cultivation. Many are now abandoned-field pastures and support little useful vegetation.

On other types of land, the rate of decrease in productivity is intermediate. The shallow crumbly soils and the tight soils of the prairies show more evidence of decreased soil fertility than the deep crumbly heavy blackland soils. The latter are very strong soils that have withstood cropping without soil maintenance unusually well for soils of uplands; nevertheless, the need for improved soil management is quite apparent. The increase in yields obtained on areas where legumes have been fertilized with phosphate and turned under, together with comparison of yields on relatively new and old soils, indicate that the prevailing yields on these soils are probably a little less than three-fourths as large as those that would be obtained at the original level of fertility.

The plowing under of legumes has been successfully used to a slight extent in the area to improve soil fertility. Although this practice is rapidly spreading, it has been adopted very recently and, as yet, on only a small proportion of the cropland. Hubam clover, Austrian Winter peas, and vetch are the principal legumes, but some cowpeas have been used, especially on the sandier soils. Crotalaria, though not commonly grown, is also a good summer legume for the sandy soils. It is deep rooted, makes a good growth late in summer when moisture is insufficient for cowpeas, and is not injured by nematodes, or root knot.

Commercial fertilizers have been tried by a few farmers, but their use has been restricted mainly to the light-colored sandy soils. In recent years phosphate fertilizers have been used to a slight extent, and the results obtained indicate that their use is profitable, especially for fall-planted legumes. In all cases, the fertilizer should be placed under the seed for best results.

Most farmers alternate crops to some extent but follow no definite rotation. Except for the slight reduction in the amount of cotton root rot following certain crops, there is little evidence that any particular sequence of crops without legumes is better than any other sequence. Yields following corn or small grains tend to be somewhat higher than those following crops that mature late in the fall. Sorghums commonly depress yields the following year unless the stubble is plowed under early in the fall. Fairly satisfactory rotations that include cotton, small grains with Hubam clover, and corn or sorghums can be used on the soils of the prairies. Corn, winter legumes (with phosphate applied) for green manure, cotton, and

sorghums or special crops can be used on the sandy soils. Such rotations will aid materially in maintaining the soil fertility and in reducing erosion.

Contour tillage and terracing are the principal methods used in McLennan County for controlling erosion of cropland. Soil Conservation Service representatives estimate that in 1953 between 14,000 and 16,000 acres was adequately terraced and had protected terrace outlets. Several times that acreage has been terraced in some fashion or other, but the outlets were unprotected and many of the terraces were of insufficient width and height or of incorrect design. More harm than good is usually the result of improper terracing. Stripcropping is effective on short gentle slopes that do not have gullies or rills, but most farmers prefer terracing.

Information contained in this report indicates that of the 453,000 acres in cultivation in 1943, 53,000 acres was bottom land with no likelihood of erosion and 90,000 was level upland without significant erosion hazard. The remaining acreage was more or less sloping upland subject to erosion in varying degrees. Of this upland, 9,000 acres was clearly unsuited to crops because of strong slope, severe erosion, or other reasons; 47,000 acres was sloping (gradients of 4 to 8 percent) somewhat arable soils, very susceptible to erosion, on which considerable erosion occurred under clean-tilled crops, even when the soil was well terraced and contour cultivated. About 250,000 acres was gently sloping (gradients of 1 to 4 percent) upland, slightly to moderately susceptible to erosion, on which intertilled crops could be grown most of the time without serious erosion if the soil were properly terraced and contour cultivated.

The reduction in the fertility of the soils of McLennan County is due mainly to (1) the loss of soil and valuable plant nutrients by erosion and (2) cropping that has removed plant nutrients. Soil fertility cannot be maintained if plant nutrients are removed by crops and erosion and none are returned. There is a gradual to rapid decline under such a system that, although not obvious at first, will eventually render the most productive soils practically unsuitable for cultivation. Some areas of sloping once-productive farmland in the county have already reached this condition and are now in abandoned-field pastures of low carrying capacity. Other areas are of such low productivity as a result of exhaustive cropping and erosion that they are of marginal value and soon will be unsuited as cropland if the present system of farming is continued.

AGRONOMIC SOIL GROUPS

In considering problems of land use and soil management it is convenient to have the many soils of an area combined into groups on the basis of agronomic characteristics. Such a grouping of the soils of McLennan County is given in this section. This grouping is necessarily interpretive and more or less arbitrary; somewhat different groupings might be made with equal justification. The groups are numbered for convenience in discussing them, and the sequence of numbers is not necessarily an indication of the relative productivity or value of the group.

FIRST-CLASS SOILS

Fertile well-drained soils of bottom lands.—Alluvial soils with slight to moderate flood hazard, medium to slow internal drainage, and good moisture-holding capacity; excellent for nearly all crops.

Group 1.—Medium-textured soils with medium internal drainage:
- Asa silt loam, 0 to 1 percent slopes.
- Asa silty clay loam, 0 to 1 percent slopes.
- Asa very fine sandy loam, 0 to 1 percent slopes.
- Catalpa clay loam, 0 to 1 percent slopes, occasionally flooded.
- Catalpa clay loam, 1 to 4 percent slopes.
- Norwood silt loam, 0 to 1 percent slopes.
- Norwood silty clay loam, 0 to 1 percent slopes.

Group 2.—Heavy-textured soils with slow to medium internal drainage:
- Catalpa clay, 0 to 1 percent slopes, occasionally flooded.
- Catalpa clay, 1 to 4 percent slopes.
- Miller clay, 0 to 1 percent slopes.

Deep crumbly heavy soils of prairies.—Very good for most field crops; suited to alfalfa where not infested with cotton root rot; excellent for pasture.

Very slow internal drainage; not particularly suited to small grains:

Group 3.—Gently sloping with slight to moderate susceptibility to erosion:
- Bell clay, 1 to 4 percent slopes.
- Burleson-Houston clays, 1 to 3 percent slopes.
- Houston Black clay, 1 to 4 percent slopes.
- Houston Black gravelly clay, 1 to 4 percent slopes.
- Houston clay, 1 to 4 percent slopes.

Group 4.—Nearly level; little or no susceptibility to erosion:
- Bell clay, 0 to 1 percent slopes.
- Bell clay, noncalcareous variant, 0 to 1 percent slopes.
- Houston Black clay, 0 to 1 percent slopes.
- San Saba clay, 0 to 2 percent slopes.

With medium to slow internal drainage; excellent for small grains:

Group 5.—Mostly gently sloping but some level; slight to moderate susceptibility to erosion:
- Austin silty clay, 1 to 4 percent slopes.
- Brewer clay loam, 0 to 1 percent slopes.
- Crawford clay, 1 to 3 percent slopes.
- Denton clay, 1 to 4 percent slopes.
- Lewisville clay, 1 to 4 percent slopes.
- Lewisville clay, 0 to 1 percent slopes.
- Lewisville clay loam, 1 to 4 percent slopes.
- Norge clay loam, 1 to 4 percent slopes.

Brown moderately permeable loamy soils of river benches and uplands.—Fertile well-drained soils that are very responsive to management; very good for most field crops, excellent for truck crops and fruits, and good for permanent pasture.

Group 6.—Nearly level to gently sloping; no or slight susceptibility to erosion:
Bastrop fine sandy loam, 0 to 1 percent slopes.
Bastrop very fine sandy loam, 0 to 1 percent slopes.
Norge fine sandy loam, 1 to 4 percent slopes.
Vanoss fine sandy loam, 0 to 1 percent slopes.
Vanoss silt loam, 0 to 1 percent slopes.

SECOND-CLASS SOILS

Deep tight soils of grasslands.—Moderately fertile soils with compact subsoils; crusty and somewhat droughty; good for most field crops; very good for pasture.

Group 7.—Gently sloping; slight to moderate susceptibility to erosion:
Burleson clay, 1 to 3 percent slopes.
Crockett loam, 1 to 3 percent slopes.
Irving clay loam, 1 to 3 percent slopes.
Payne clay loam, 1 to 2 percent slopes.
Riesel-Irving gravelly clay loams, 1 to 4 percent slopes.
Wilson clay loam, 1 to 3 percent slopes.

Group 8.—Level; not susceptible to erosion:
Burleson clay, 0 to 1 percent slopes.
Irving clay loam, 0 to 1 percent slopes.
Irving silt loam, 0 to 1 percent slopes.
Irving-Axtell complex, 0 to 1 percent slopes.
Ivanhoe-Irving-Axtell complex, 0 to 1 percent slopes.
Wilson clay loam, 0 to 1 percent slopes.

Gently sloping moderately shallow crumbly heavy soils of grasslands.—Good for most field crops; fair to good for corn; excellent for small grains and pasture.

Group 9.—Gently sloping; slightly to moderately susceptible to erosion:
Houston Black clay, moderately deep variant, 1 to 4 percent slopes.
Patrick clay, 1 to 4 percent slopes.
San Saba clay, shallow variant, 0 to 1 percent slopes.

Moderately fertile soils of bottom lands, with sandy subsoils.—Good for most field crops.

Group 10.—Level; occasionally overflowed:
Brazos silt loam, 0 to 1 percent slopes.
Yahola silt loam, 0 to 1 percent slopes.

THIRD-CLASS SOILS

Sloping crumbly heavy soils of grasslands.—Good for most field crops but require careful management to control erosion in cropland; very good for pasture.

Group 11.—Moderately sloping; moderately to very susceptible to erosion:
Austin silty clay, 4 to 8 percent slopes.
Houston clay, 4 to 8 percent slopes.

Krum clay, 4 to 8 percent slopes.
Lewisville clay, 4 to 8 percent slopes.
Lewisville clay loam, 4 to 8 percent slopes.
Riesel-Irving gravelly clay loams, 4 to 8 percent slopes.

Gently sloping shallow soils of grasslands.—Arable crumbly clays 7 to 18 inches deep over chalk or limestone; good for small grains; fair for most other field crops; very good for pasture.

Group 12.—Slightly to moderately susceptible to erosion:
Austin silty clay, shallow variant, 1 to 4 percent slopes.
Crawford clay, shallow variant, 1 to 3 percent slopes.
Denton clay, shallow variant, 1 to 4 percent slopes.

Gently sloping light-colored sandy loams with deep surface soils.—Timbered upland soils of favorable physical character but low natural fertility; very responsive to soil management; very good for truck crops, fruits, peanuts, and various special crops; fair to good for field crops; fertilization required for good yields; poor for pasture; fair as woodland.

Group 13.—Slightly to moderately susceptible to erosion:
Milam fine sandy loam, 1 to 4 percent slopes.
Sawyer fine sandy loam, 0 to 1 percent slopes.
Travis fine sandy loam, 1 to 4 percent slopes.

Frequently flooded fertile soils of bottom lands.—Mainly heavy clays with slow internal drainage; most areas are suited to, and productive of, field crops, but crop production is difficult and somewhat hazardous; excellent for pasture.

Group 14:
Catalpa clay, 0 to 1 percent slopes, frequently flooded.
Catalpa clay loam, 0 to 1 percent slopes, frequently flooded.
Kaufman clay loam, 0 to 1 percent slopes.
Kaufman loam, 0 to 1 percent slopes.
Pledger clay, 0 to 1 percent slopes.
Trinity clay, 0 to 1 percent slopes.

FOURTH-CLASS SOILS

Sandy soils with compact subsoils.—Acid forested soils of low natural fertility; rather droughty; poor to fair for field crops; fair for pasture and as woodland.

Group 15.—Nearly level to gently sloping; slightly to moderately susceptible to erosion:
Axtell fine sandy loam, 0 to 2 percent slopes.
Axtell very fine sandy loam, 0 to 1 percent slopes.
Hortman fine sandy loam, 2 to 4 percent slopes.
Riesel-Axtell gravelly loams, 1 to 4 percent slopes.

Very shallow arable soils of grasslands.—Fair for small grains and cultivated pasture; poor for most other crops; good for pasture.

Group 16.—Gently to moderately sloping; moderately to very susceptible to erosion:
Austin silty clay, shallow variant, 4 to 8 percent slopes.
Austin-Eddy gravelly clay loams, 1 to 4 percent slopes.

Loose deep sands of timbered uplands.—Fair to good for peanuts, watermelons, and a few other special crops; poor for most field crops and pasture.

Group 17.—Gently sloping; slight or no susceptibility to erosion:
Eufaula fine sand, 0 to 2 percent slopes.
Milam loamy fine sand, 1 to 4 percent slopes.
Stidham loamy fine sand, 0 to 2 percent slopes.

Sandy soils of first bottoms with very sandy subsoils.—Poor to fair for field crops; good for pasture; fair for woodland.

Group 18.—Infrequently flooded; not susceptible to erosion:
Brazos loamy very fine sand, 0 to 1 percent slopes.
Yahola very fine sandy loam, 0 to 1 percent slopes.

Sloping sandy soils mostly on timbered uplands.—Good to fair for tree fruits and truck; poor for most field crops and pasture; fair as woodland.

Group 19.—Sloping; mostly moderately susceptible to erosion:
Bastrop fine sandy loam, 4 to 8 percent slopes.
Hortman-Axtell fine sandy loams, 4 to 10 percent slopes.
Milam fine sandy loam, 4 to 8 percent slopes.
Riesel-Axtell gravelly loams, 4 to 8 percent slopes.
Travis fine sandy loam, 4 to 8 percent slopes.

Sloping arable tight soils of grasslands.—Poor to fair for most field crops; good for pasture.

Group 20.—Sloping; very susceptible to erosion:
Crockett loam, 3 to 8 percent slopes.
Wilson-Houston complex, 3 to 8 percent slopes.

NONARABLE SOILS

Soils of grasslands.—Good for pasture.

Group 21:
Austin silty clay, 8 to 15 percent slopes.
Crockett loam, 8 to 15 percent slopes.
Crockett clay loam, severely eroded, 3 to 8 percent slopes.
Eddy silty clay, 8 to 15 percent slopes.
Eddy gravelly clay loam, 4 to 15 percent slopes.
Ellis clay, 6 to 15 percent slopes.
Houston clay, 8 to 15 percent slopes.
Patrick gravelly clay, 2 to 15 percent slopes.
San Saba-Crawford stony clays, 1 to 2 percent slopes.
Sumter clay, 8 to 20 percent slopes.
Tarrant stony clay, 1 to 8 percent slopes.
Tarrant-Brackett stony clays, 8 to 20 percent slopes.
Wilson-Houston complex, 8 to 15 percent slopes.

Soils of bottom lands.—Good for pasture or woodland.

Group 22:
Alluvial soils, undifferentiated, 0 to 1 percent slopes.
Broken land, Catalpa soil material.
Catalpa gravelly clay loam, 0 to 1 percent slopes.

Rough and waste lands.—Of low value for agriculture or forestry.

Group 23:

Eddy gravelly clay loam, 15 to 50 percent slopes.
Riverwash.
Rough broken land.
Rough stony land, Brackett soil material.

GROUPS 1 AND 2

The soils of groups 1 and 2 have not been affected by erosion. These soils are moderately to highly productive, and their yields have declined very little since they were first put in cultivation. The increase or maintenance of fertility in these soils is usually given little thought, yet it is probable that economical increases in yields can be obtained under better soil management. In many cases cotton and corn that follow alfalfa have shown yield increases of 15 to 30 percent for periods lasting 2 to 3 years. Somewhat similar responses might be expected from crops following Hubam clover. These results indicate that these soils are deficient in nitrogen.

It has been found that the use of 100 to 300 pounds of cyanamid alone,[5] or 500 pounds of 4–8–4 fertilizer, on soils of the Brazos River bottom (Miller and Yahola soils) produced increases in yields ranging from 7.5 to 43.5 percent, or an average of 23.5 percent more than the unfertilized soil, and that cyanamid alone, which contains only nitrogen, produced as large yields in general as the mixed fertilizer. Apparently the addition of nitrogen, either in commercial fertilizer or by growing legumes, will give economical increases on the soils of groups 1 and 2. Alfalfa should be grown as often as feasible, as it produces a valuable hay crop and adds nitrogen and organic matter to the soil.

GROUPS 3 AND 4

Generally fertilization of cotton on blackland soils [6] does not increase the yields enough to pay the cost of fertilizer. However, if phosphate fertilizers are supplied to inoculated legumes preceding cotton and corn, the good responses of the legumes are reflected in the increased yields of the succeeding cotton and corn crops. On soils of groups 3 and 4, Austrian Winter peas, vetch, or Hubam clover are satisfactory legumes for planting in regular rotation with row crops for maintenance or improvement of soil productivity. Vetch and Austrian Winter peas should be inoculated and planted in the fall and supplied with phosphate fertilizer. These crops can be turned under in the spring and followed by cotton. Hubam clover may be planted in fall and, if it makes enough growth, turned under in the spring and followed by cotton. If sufficient growth is not made, as is often the case, the clover is allowed to mature seed for harvesting by a combine, and the straw is left in the fields for soil improvement. If moisture is adequate, the land may then be planted to grain sorghums the same season or planted to cotton the following spring.

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[5] Texas Agricultural Experiment Station. Texas agricultural experiment station 46th annual report. 257 pp. 1933.

[6] Reynolds, E. B., McNess, G. T., Hall, R. A., and Others. Fertilizer experiments with cotton. Tex. Agri. Expt. Sta. Bul. 469, 31 pp. 1932.

The soils of group 3, if gullies and rills are present, should be properly terraced and contour cultivated, and legumes used in the rotation. Alfalfa can be grown successfully on some of the soils of this group and is suggested where root rot is not prevalent.

GROUP 5

The use of legumes, phosphate fertilizer, terraces, and contour cultivation, as suggested for soils of groups 3 and 4, is applicable for soils of group 5. The soils of group 5 are excellent for small grains. A very satisfactory rotation of corn, oats with Hubam clover, and cotton can be followed on them. The Hubam clover is generally seeded over the small grain in the winter; after the small grain is harvested the clover can be grazed or left to mature seed for harvest. Terraces are not needed on Lewisville clay, 0 to 1 percent slopes, and are usually not necessary on the gently sloping soils having no gullies or rills if cover is provided.

GROUP 6

The soils of group 6 are among the most productive and desirable soils of the county for growing general and special crops. They are also among the most responsive to good management. Austrian Winter peas or vetch, when inoculated and fertilized with about 150 to 200 pounds of 20 percent superphosphate an acre and turned under in the spring before cotton is planted, will give average increases of 20 to 35 percent. Hubam clover also does well on these soils and produces a good seed crop. If it is used in the rotation about 1 year in 3 or 4, yields of other crops will be maintained or increased. Alfalfa is not generally grown on soils of this group, but if inoculated and fertilized with phosphate, it should produce moderate to high yields of hay. Cowpeas also do well on these soils and are good summer legumes for soil improvement. Terraces are not needed on the Vanoss or Bastrop soils of group 6, but areas of Norge fine sandy loam, 1 to 4 percent slopes, with gullies and rills should be terraced and contour farmed.

GROUPS 7 AND 8

The soils of groups 7 and 8 are crusty and somewhat droughty because they have heavy claypan subsoils. The use of deep-rooted legumes like Hubam clover, or of green-manure crops of Austrian Winter peas or vetch, will aid considerably in improving the tilth and productivity of these soils. Use of phosphate fertilizers with inoculated legumes is suggested as often as feasible, and these should be used at least 1 year in 3. Satisfactory rotations for these soils are: (1) Corn, oats with Hubam clover, and cotton; or (2) corn, Austrian Winter peas or vetch turned under for green manure, cotton, and oats. Grain sorghums may replace corn in the rotation, and cotton should follow the green-manure crop. If such rotations as these are used, little if any change in the acreage of cash crops is needed and the fertility of the soil is maintained or increased. Terraces are not needed on the level soils of group 8, but properly constructed terraces and contour cultivation should be used on the soils of group 7 to conserve both soil and moisture.

GROUP 9

The soils of group 9 have about the same requirements for good management as those of group 5. However, they are shallower, have a restricted root-feeding zone, and, as a rule, are somewhat more droughty. As they are used mainly for growing cotton, oats, corn, and sorghums, satisfactory rotations are those that include Hubam clover, vetch, Austrian Winter peas, or a similar legume about 1 year in 4. If phosphate fertilizer is used under the legumes, the productivity of these soils can be increased. The more sloping areas should be terraced and contour farmed to reduce soil loss.

GROUP 10

The soils of group 10 are similar to the soils of group 1 in their requirements for good management. They have sandier subsoils, however, and are somewhat less productive. In addition, crops on them do not withstand droughts so well as on the soils of group 1. To add nitrogen to the soils of group 10, inoculated Hubam clover fertilized with phosphate fertilizer can be used in a crop rotation with corn and cotton. If alfalfa is grown, no other legume crop is needed during the following 2 or 3 years. Vetch or Austrian Winter peas may be used as a green-manure crop to be followed by cotton, if the cash crop is cotton instead of Hubam clover for seed. The natural fertility of these soils is relatively high, and a legume grown about 1 year in 4, for green manure, seed, or hay, will increase the nitrogen content of the soils and maintain or increase the yields of such crops as cotton, corn, or sorghums.

GROUP 11

The soils of group 11 were moderately productive when first placed in cultivation, but yields of crops have declined as much as 50 percent on most of them because of the removal of plant nutrients by erosion and by cropping. Erosion control is the first management requirement. The fertility cannot be maintained by other means if the topsoil is removed by erosion faster than it is formed. Practically all soils of this group, if kept in cultivation, should be properly terraced; outlets should be well grassed before terraces are constructed; rows should be on the contour; and at least one-third of the cultivated land should be planted to erosion resisting crops such as small grains, broadcast sorghums, sudangrass, or millet.

These soils have about the same fertilizer requirements and responses as the soils of groups 3 and 4. Complete fertilizers generally do not increase the yields enough to pay the cost. Inoculated legumes, fertilized with phosphate, have increased growth and economically increased the yields of following crops of corn, cotton, or grain sorghums. Hubam clover, Austrian Winter peas, or vetch are among the legumes most successful on these soils. A 3-year rotation of (1) cotton, oats overseeded with Hubam clover, and corn or (2) corn, Austrian Winter peas or vetch seeded in the corn, cotton, and sorghums will maintain or increase the productivity of these erodible soils if they are adequately terraced.

GROUP 12

The soils of group 12 have physical characteristics very favorable for cultivation. Because of the rather thin soil, however, they cannot store large quantities of moisture, and summer crops are more susceptible to drought than on deeper soils. Small grains produce yields almost equal to those on deeper soils, and the rotation should be centered around these crops. Because of the shallowness of the soils of this group, terraces are not feasible on many areas and erosion control must necessarily be mostly by vegetative measures. Small grains overseeded with Hubam clover and alternating with cotton or grain sorghums give fairly effective erosion control and maintain the nitrogen supply. Austrian Winter peas or vetch planted for green manure and followed by cotton and small grains also makes a satisfactory rotation. Legumes should be inoculated and receive phosphate fertilizer at planting time. The very shallow sloping eroded areas should be retired from cultivation and seeded to adapted native grasses. A legume should be turned under or left on the land before these areas are seeded or sodded for pasture.

GROUP 13

The soils of group 13 are similar to the sandy soils of east Texas in fertilizer requirements and response to management. These soils are deficient in nitrogen, phosphorus, and potassium. Tests conducted at the Texas Agricultural Experiment Substation located at Tyler showed that plowing under vetch fertilized with superphosphate and potash practically doubled the yield of corn and increased the yield of cotton 80 percent. The application of 200 to 400 pounds an acre of 4-12-4 or 4-8-4 fertilizer, or of fertilizer supplying similar amounts of plant nutrients, is suggested for cotton on the sandy soils of east Texas.[7] Comparable responses to fertilizer or green manure can be expected from the soils of group 13. Cowpeas or mungbeans produce well on these soils; either can be planted alone, the seed harvested, and the vines left on the land or turned under for soil improvement. Cowpeas and mungbeans can be grown in alternate rows of corn and handled in the same manner. Crotalaria can be used for soil improvement by planting it following harvest of a special crop or truck crop. Terracing and contour cultivation may be necessary on the more sloping and erodible areas, especially if gullies and rills are present.

GROUP 14

The soils of group 14 are naturally very productive, but crop production is difficult and hazardous because of overflows. Protection from overflow is the most important immediate management need for these soils, but this is not feasible from the individual owner's standpoint. A practice that appears practical is growing a legume about 1 year in 4 to increase the nitrogen supply in the soil. The more frequently flooded lower lying areas on which crop production is uncertain or unprofitable can be sodded to bermudagrass for pasture. Well-sodded pastures of bermudagrass that are mowed to

[7] See footnote 6, p. 97.

control weeds have a carrying capacity of 1 cow to 2 acres, which is probably a greater return than if the land were cultivated.

GROUP 15

The soils of group 15 are of low natural fertility and somewhat droughty but are responsive to soil management and can be made rather productive. Crops on these soils respond well both to complete fertilizers and to green-manure crops of legumes. Because of the compact subsoils of this group, crops do not withstand long dry periods. Crops that mature in spring and early in summer therefore should be planted as much as possible. These soils are similar to a soil (Lufkin fine sandy loam) tested at College Station, Texas. The results of 15 years of tests at that station clearly show that the soils respond to applications of nitrogen, phosphorus, and potash, and that a 4-12-4 fertilizer applied at the rate of 400 pounds an acre gives good results. The results obtained over a 10-year period also show that plowing under vetch that had received 500 pounds an acre of 0-8-4 fertilizer increased the yield of cotton 40 percent.

Cowpeas also do fairly well on these soils. They are easily included in the cropping system and serve the dual purpose of adding nitrogen to the soil and of producing a seed crop that can be harvested. Crotalaria, although not commonly grown in the county, is a deep-rooted summer legume that should do well on these soils. Hubam clover needs applications of phosphorus, and probably lime, for successful growth. Areas of these soils moderately eroded should be terraced and contour-cultivated if used for crops. Areas with numerous gullies and rills should be sodded to bermudagrass for pasture after a crop of legumes fertilized with phosphate has been turned under.

GROUPS 16 TO 20

The Fourth-class soils of the county, as a whole, are of marginal value for cropland and best suited to pasture. Many of these soils, however, occur in small areas where cultivation is feasible. The following suggestions for management of soils of groups 16 to 20 are made under the assumption that the soils are to be used for special or specified crops and not for various kinds of general field crops.

The soils of group 16 are best suited to small grains, sudangrass, or pasture. Probably the most satisfactory rotation for maintaining or improving the productivity of croplands consists of small grains and Hubam clover. The small grain is overseeded with Hubam clover during winter or early in spring. The grain is harvested, and the clover is grazed during the summer after sufficient growth, or it is allowed to mature for seed. If the seed is harvested, some grazing is obtained before the land is plowed for fall seeding to small grain.

In some parts of the country sweetclover and oats are planted in alternate drill-rows 14 to 16 inches apart, and good yields of each crop are obtained. This method should be successful on these shallow soils if oats and Hubam clover were planted. Phosphate fertilizer will increase the growth of the clover and the yields of the following grain crop. These soils are too thin for terracing. Areas that require terracing for erosion control should be retired to pasture and seeded to adapted native grasses.

The soils of group 17 are of low natural fertility but are well suited to special crops. Except in some areas and under favorable conditions, they are not well suited to most field crops and pasture because they have low productivity and are susceptibile to leaching. When these soils are used for special crops, large amounts of complete fertilizer, ranging from 400 to 1,000 pounds an acre, are needed. Continual replenishment of organic matter is also desirable to reduce leaching and to maintain an adequate supply of nitrogen. Nitrogen can be added by using summer legumes (cowpeas or crotalaria), or by turning under vetch or Austrian Winter peas fertilized with 200 to 300 pounds of superphosphate.

These soils are not susceptible to water erosion, but some soil blowing occurs when they are bare. Soil blowing can be controlled effectively by leaving crop residues on the surface or by following clean-tilled crops of early vegetables or peanuts with cover crops, planted either in summer or fall.

The natural fertility of the soils of group 18 was but moderate when they were first placed in cultivation and has declined considerably under the row-crop system of farming. The productivity of these soils can be restored or increased by the use of legumes about 1 year in 3 or 4 in a rotation with corn, cotton, or grain sorghums. Hubam clover may be used to produce seed to be harvested (the straw left on the land), or vetch or Austrian Winter peas may be turned under and followed by cotton. Legumes for soil improvement need phosphate fertilizer.

The soils of group 19 differ from those of group 13 mainly in having more sloping surfaces and greater susceptibility to erosion. The fertilizer applications and legumes suggested for group 13 are appropriate on these soils. All cultivated land should be terraced and contour cultivated. Winter cover crops of vetch or Austrian Winter peas (which are turned under in the spring for green manure) and erosion-resisting summer crops, including legumes, should be used as often as possible. The more eroded sloping areas on which good soil management is not feasible should be retired to pasture and seeded or sodded to bermudagrass, bluestem, or other adapted grasses. A legume crop fertilized with phosphate should be turned under before seeding or sodding for pasture.

The soils of group 20 have about the same physical characteristics and crop adaptations as those of group 7. However, they are more sloping and more susceptible to erosion, and they have been damaged more by erosion and exhaustive cropping than the soils of group 7. The first requirement in management for these soils is the control of erosion. They are of low productivity, and many areas are better suited to pasture or native meadow than to crops. Where kept in cultivation, these soils need proper terracing, contour cultivation, and planting to erosion-resisting crops at least 1 year in 3. The fertilizers, legumes, and crop rotations given for soils of groups 7 and 8 are applicable to this group. The more sloping and eroded areas and those on which satisfactory soil management is not feasible should be retired to pasture and seeded or sodded to bluestem and bermudagrass after a legume crop has been turned under.

GROUPS 21 TO 23

The members of groups 21 to 23 are nonarable soils and land types physically unsuited to cultivation but of low to high value as pasture. The intensity of use and management will depend largely on their location in relation to arable soils. Intensive treatment will be practical for many small areas that occur in association with large areas of arable soils but would not be feasible for large areas not associated with arable soils.

The soils of group 21 are mainly strongly sloping prairies that originally supported a thick stand of highly nutritious grasses. Many areas have been cultivated; they are now eroded, abandoned-field pasture. Many others have been overgrazed and are covered with weeds and few desirable pasture grasses. Pastures of rather high carrying capacity can be developed on all these areas if they are carefully managed. Weeds and brush can be controlled, and grazing should be regulated so that native grasses can spread naturally. Where the stand of native grasses is very thin, overseeding may be feasible. Areas that have been cultivated and have no vegetation of economic value need establishment of good pasture grasses. If you have soils of this kind, see your local SCS conservationist or county agent. They will give you information on kinds of grasses to seed and tell you how to do the job.

Controlled grazing, weed control by mowing or by grazing with sheep, and brush control are profitable practices.

The soils of group 22 are on bottom lands unsuitable for cultivation, but they provide excellent pasture if they are cleared and sodded to bermudagrass, Hubam clover, and burclover. Control of weeds and brush is necessary on open areas, and some clearing of brush from wooded areas may be feasible.

The rough and waste lands of group 23 require little treatment except controlled grazing. Ask your local Soil Conservation District for help in soil management, best land use, and suitable erosion control.

EROSION AND EROSION CONTROL

The percentage of each geographic subdivision (Brazos River bottoms, Grand Prairie, sandy forested uplands, and Blackland Prairie) in the four erosion classes recognized in the survey is given in table 6. This table shows that erosion, due mainly to poor soil management that includes improper land use, is a serious problem on soils of the uplands of the county.

The soils of the Brazos River bottoms proper are not affected by erosion. The 5.61 percent of this geographic subdivision (table 6) affected by moderate or more severe erosion occurs on relatively short slopes between low terraces and the flood plain or between levels of low terraces. The areas with moderate erosion do not constitute an important hazard, as erosion can be effectively controlled by vegetation without necessarily involving a change in land use. Annual or perennial crops of sorgo, Hubam clover, alfalfa, or little bluestem, planted in wide strips or bands on the contour, are effective on most areas. The moderately severe and severe erosion occurs entirely on

TABLE 6.—*Erosion by geographic subdivisions in McLennan County, Tex.*

Geographic subdivisions	No or slight erosion		Moderate erosion		Moderately severe erosion		Severe erosion		Total
	Acres	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*	*Percent*	*Acres*
Blackland prairie section:									
Blackland prairie proper	223, 000	55. 79	116, 400	29. 12	49, 200	12. 31	11, 100	2. 78	399, 700
Brazos River bottoms [1]	42, 100	94. 39	1, 300	2. 91	400	. 90	800	1. 80	44, 600
Sandy forested uplands	27, 000	73. 57	7, 300	19. 89	2, 200	6. 00	200	. 54	36, 700
Grand Prairie	151, 400	84. 84	26, 600	14. 94	400	. 22	--------	0	178, 400
Total	443, 500	67. 24	151, 600	23. 00	52, 200	7. 92	12, 100	1. 84	[2] 659, 400

[1] Comprise the flood plains of the Brazos River and border low terraces occupied by Bastrop, Brewer, and Vanoss soils.
[2] Does not include 6,600 acres of water area (Grand Prairie, 100 acres; Blackland Prairie, 3,800; and Brazos River bottoms, 2,700.)

Bastrop fine sandy loam, 4 to 8 percent slopes. These eroded areas are on the slopes above overflow between nearly level terraces or between low terraces and the flood plain. They are small, as a rule, and erosion can be controlled by terraces and contour cultivation supplemented by strips of erosion-resisting crops or by permanent vegetation. Most of these areas are located near farmsteads. They could therefore well be terraced and used for orchards in which both summer and winter legumes are the only crops grown, or they could be seeded and sodded to bermudagrass, burclover, and Hubam clover and used for permanent pasture.

Only about 15 percent of the Grand Prairie (table 6) has moderate or moderately severe erosion, and none has severe erosion. The inextensiveness of erosion is due partly to the large percentage of the area in permanent grass and to the cropping system that centers around small-grain production. Erosion in this geographic subdivision can be effectively and economically controlled by terraces and contour cultivation, or by contour cultivation and stripcropping with erosion-resisting crops. Field stripping—planting alternate wide strips of erosion-resisting crops and row crops at right angles to the slope—is effective on the gentle slopes cut by gullies and rills.

Because of their inherent low fertility, the sandy forested uplands are readily injured by moderate erosion. As shown in table 6, a little more than 26 percent of these soils is affected by moderate to severe erosion, but less than 7 percent of this is moderately severe or severe. Most of the soils can be restored to their original fertility and the productivity increased by good management. An adequate system of terraces, crop rotations including a legume every 3 years, green-manure crops of legumes fertilized with phosphate, and the use of complete fertilizers when green-manure crops are not grown will maintain or increase the productivity of these soils and reduce erosion to a minimum. Areas of severely eroded soils and those on which good soil management is not feasible should be sodded to bermudagrass for pasture.

The Blackland Prairie, as shown by table 6, is more affected by erosion than any other geographic subdivision. About 44 percent of the entire area is affected by moderate to severe erosion. The extensive erosion on this subdivision is due to (1) a combination of soils susceptible to erosion, (2) a high percentage of cultivated land, (3) a system of farming in which clean-tilled row crops are dominant, and (4) improper use of sloping very erodible soils for cropland instead of for perennial grass.

On moderately eroded areas of the Blackland Prairie without gullies and rills, erosion can be controlled by stripcropping and contour cultivation. Because of the difficulty in harvesting, grazing, or maintaining strips and the lack of adapted erosion-resisting crops, most farmers prefer to terrace these areas as well as those having gullies and rills. Generally if legumes for green manure and crop rotations that include legumes and erosion-resisting crops are used, stripcropping is not necessary on areas with moderate erosion that have been terraced. Areas affected by moderately severe erosion should be terraced and contour cultivated. In addition, at least one-third of their acreage

should be planted to erosion-resisting crops each year. This may be done by planting one-third of the land to clover and soil-improving crops each year, with the use of needed fertilizer. Severely eroded areas should in most cases be seeded and sodded to adapted grasses and legumes and retired to pasture. If kept in cultivation, they need treatment similar to that for moderately eroded areas, but at least one-half the area should be in erosion-resisting crops for the first few years after terraces are constructed. Soil-management practices as outlined for the different soil groups in the section, Agronomic Soil Groups, should be used with terraces as well as on areas where terraces are not considered necessary.

The importance of terrace outlets and terrace maintenance cannot be overstressed. Many of the worst gullies in the county originated at unprotected terrace outlets. A good sod of permanent grass has proved most successful protection for terrace outlets. Where there are no naturally grassed areas into which the terraces can be emptied, bermudagrass is generally best for sodding a waterway. Current specifications of SCS call for terraces with low gradient, nowhere more than 3 inches fall per 100 feet of terrace length, a broad base (if ridge type is used), and about 18 inches effective height after settling. Channel-type terraces, constructed by moving all the soil downhill from the upper side of the terrace and leaving a broad shallow flat-bottomed channel, are preferred by some instead of ridge-type terraces. Terraces should be maintained each year or as often as the soil is plowed.

The Soil Conservation Service maintains technicians in Waco, West, and McGregor to give assistance to farmers in planning programs for erosion control. They should be consulted for additional and detailed information concerning specific farms or areas.

SEEDBED PREPARATION, DISEASES, AND INSECTS

Land preparation for cotton and other row crops usually consists of cutting the stalks of the preceding crop with a stalk cutter and listing once or twice. Following oats and other broadcast crops, the soil is plowed, usually to a depth of 4 or 5 inches. Any method of land preparation that controls weeds, saves the crop residues, and furnishes a crumbly seedbed seems equally effective. On clean-tilled areas, these results are accomplished with less labor by listing than by plowing. Nearly all of the soils of the county have favorable tilth, and a good seedbed may usually be obtained with little difficulty. An occasional deep plowing, say once every 5 or 10 years, may benefit fields in which a plowsole tends to develop, but there is nothing to indicate that deep plowing every year would be a good practice. Diskplows are generally used instead of moldboard plows on the clay soils, which do not shed well from tillage implements.

The most important disease affecting crops in McLennan County is cotton root rot. This disease "lives over" in the soil, and its distribution is related to soil type. It is widespread on all of the heavier and more limy prairie soils, is of slight extent on the tight prairie soils, and is essentially absent on the first bottoms and sandy timbered up-

lands. The disease affects cotton and nearly all other tap-rooted crops except grasses. There is no known practical method of eliminating the disease from a field in which it has become established. Long rotations that include two or more successive nonsusceptible crops, green manuring with legumes, and fertilization to hasten crop maturity afford some control of the disease. This disease limits the legumes that may be used to varieties that are resistant or that make their principal growth during the cooler seasons when the disease is inactive. Alfalfa is seriously affected; certain varieties of cowpeas are resistant; Hubam clover and winter legumes commonly mature before cotton root rot has become active.

Injury by cotton insects is the partial cause of the relatively low average cotton yield in the county as a whole. The insects that do most damage are the cotton boll weevil, fleahopper, bollworm, and leafworm. All of these can be controlled by proper use of insecticides. Information as to the proper methods of poisoning these insects can be obtained from the county agricultural agent. A few of the more successful farmers, especially some of the larger landowners in the Brazos River bottoms, use insecticides for boll weevil, fleahopper, and bollworm with good success. Many farmers poison the leafworm.

ESTIMATED YIELDS

The estimated average acre yields of the principal crops that may be expected over a period of years on the soils of McLennan County are given in table 7. The yields listed in columns A are average yields that can be expected over a period of years on all areas within the county where management practices remain about the same as they were at the time of the survey. These average yields were considerably lower than those obtained by good farmers, since indifferent soil management was prevalent.

The yields listed under columns B are those to be expected if all improved practices that have proved successful in the area are followed. On cropland, this superior management involves use of adapted high-yielding varieties, contour cultivation and terracing where necessary for conservation of soil and moisture, green manuring with legumes, and control of crop pests and diseases. For most soils, the estimated yields under superior management are those obtainable without commercial fertilizer or soil amendments; however, those for the sandy forested uplands are obtained with the use of fertilizers. The yields of certain crops under prevailing management or under superior management have been omitted for soils that are not suited to these crops or that are not commonly used for them.

The estimated productivity of pasture is expressed in cow-acre-days.[8] The estimates refer primarily to pastures made up of native plants; superior management for pasture involves proper stocking, control of weeds, establishment of the best-adapted forage plants, and on the sandy forested uplands, the use of fertilizer and lime. If no productivity is shown in table 7, an insignificant amount of the soil is in pasture, or none at all.

[8] See footnote 1, table 7.

TABLE 7.—*Estimated average acre yields of principal crops that may be expected over a period of years on the soils of McLennan County, Tex., under two levels of management*

[Yields in columns A are those obtained under prevailing management; yields in columns B may be expected under superior management. Blank spaces indicate that the soil is not suited to the crop or is not commonly used for it]

Soil	Cotton lint		Corn		Oats		Grain sorghums		Wheat		Peanuts		Sorgo		Alfalfa		Pasture		Land class	Agronomic group
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B		
	Lb.	*Lb.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Cow-acre-days*[1]	*Cow-acre-days*[1]		
Alluvial soils, undifferentiated, 0 to 1 percent slopes																	40	50	(2)	22
Asa series:																				
Asa silt loam, 0 to 1 percent slopes	225	325	35	45			35	45					4	4	4	4		180	1	1
Asa silty clay loam, 0 to 1 percent slopes	225	325	35	45			35	45					4	4	4	4		180	1	1
Asa very fine sandy loam, 0 to 1 percent slopes	225	325	35	45			35	45					4	4	4	4	60	160	1	1
Austin series:																				
Austin silty clay, 1 to 4 percent slopes	175	250	20	40	35	50	20	40	15	20			3				75	100	1	5
Austin silty clay, 4 to 8 percent slopes	120	200	12	30	30	40	12	30	14	18			2	3		3	50	70	3	11
Austin silty clay, 8 to 15 percent slopes																	40	50	(2)	21
Austin silty clay, shallow variant, 1 to 4 percent slopes	120	160	12	20	30	40	12	20	12	15			2	3		3	40	50	3	12
Austin silty clay, shallow variant, 4 to 8 percent slopes	100	150	10	17	25	35	10	17					1½	2		2	40	50	4	16
Austin-Eddy gravelly clay loams, 1 to 4 percent slopes	80				20	25											25	40	4	16
Axtell series:																				
Axtell fine sandy loam, 0 to 2 percent slopes	80	200	8	25	15		10	25					1	2		2	20	40	4	15
Axtell very fine sandy loam, 0 to 1 percent slopes	80	180	8	25	15		10	25					1	1½		1½	20	40	4	15
Bastrop series:																				
Bastrop fine sandy loam, 0 to 1 percent slopes	140	250	18	35			35				30	45	3	3		3	60	140	1	6
Bastrop fine sandy loam, 4 to 8 percent slopes	80	200	8	30			8	30			25	35	1	2		2	15	50	4	19
Bastrop very fine sandy loam, 0 to 1 percent slopes	160	250	20	35			20	35			35	50	2	3		3	60	140	1	6
Bell series:																				
Bell clay, 0 to 1 percent slopes	200	250	25	35	30	40	25	35					3	4		4	80	160	1	4
Bell clay, 1 to 4 percent slopes	180	250	20	35	30	40	20	35					3				75	100	1	3
Bell clay, noncalcareous variant, 0 to 1 percent slopes	200	250	25	35	30	40	25	35					3	4		4	80	160	1	4
Brazos series:																				
Brazos loamy very fine sand, 0 to 1 percent slopes	100	150	10	17				17									50	60	4	18
Brazos silt loam, 0 to 1 percent slopes	160	200	20	30	30		20	30					2½	3½	2½	3½		100	2	10

[1] Cow-acre-days is the number of days one cow can be pastured on one acre.

Brewer series:																				
Brewer clay loam, 0 to 1 percent slopes	180	250	20	35	30	40	20	35					3	4	3	4	75	100	1	4
Broken land, Catalpa soil material																	80	100	(2)	22
Burleson series:																				
Burleson clay, 0 to 1 percent slopes	180	225	17	30	30	40	17	30					3	4		4		80	2	8
Burleson clay, 1 to 3 percent slopes	180	225	17	30	30	40	18	30					3	4		4	60	80	2	7
Burleson-Houston clays, 1 to 3 percent slopes	180	250	20	35	30	40	20	35					3	4		4	70	100	1	3
Catalpa series:																				
Catalpa clay, 0 to 1 percent slopes, occasionally flooded	225	325	30	45			35	45					4	4	4	4	70	180	1	2
Catalpa clay, 1 to 4 percent slopes	225	325	35	45			35	45					4	4	4	4	70	180	1	2
Catalpa clay, 0 to 1 percent slopes, frequently flooded	150	200	22	35			22	35					3	4		4	50	180	3	14
Catalpa clay loam, 0 to 1 percent slopes, occasionally flooded	225	325	35	45			35	45					4	4	4	4	70	180	1	1
Catalpa clay loam, 1 to 4 percent slopes	225	325	35	45			35	45					4	4	4	4	70	180	1	1
Catalpa clay loam, 0 to 1 percent slopes, frequently flooded	150	200	22	35			22	35					3	4		4	50	180	3	14
Catalpa gravelly clay loam, 0 to 1 percent slopes																	70	90	(2)	22
Crawford series:																				
Crawford clay, 1 to 3 percent slopes	180	250	20	35	35	50	20	35	20	30			3	4		4	75	100	1	5
Crawford clay, shallow variant, 1 to 3 percent slopes	120	160	12	20	30	35	12	20	12	15							40	70	3	12
Crockett series:																				
Crockett loam, 1 to 3 percent slopes	120	225	12	25	25	35	15	25					2	3		3	40	60	2	7
Crockett loam, 3 to 8 percent slopes	100	150	10	17	20	30	10	17					1½	2		2	30	40	4	20
Crockett loam, 8 to 15 percent slopes																	40	40	(2)	21
Crockett clay loam, severely eroded, 3 to 8 percent slopes																	10	30	(2)	21
Denton series:																				
Denton clay, 1 to 4 percent slopes	180	250	20	35	35	50	20	35	15	22			3	4		4	75	100	1	5
Denton clay, shallow variant, 1 to 4 percent slopes	120	160	12	20	30	35	12	20	12	15							40	50	3	12
Eddy series:																				
Eddy gravelly clay loam, 4 to 15 percent slopes																	20	30	(2)	21
Eddy gravelly clay loam, 15 to 50 percent slopes																	10	10	(2)	23
Eddy silty clay, 8 to 15 percent slopes																	20	50	(2)	21
Ellis series:																				
Ellis clay, 6 to 15 percent slopes																	40	40	(2)	21
Eufaula series:																				
Eufaula fine sand, 0 to 2 percent slopes	40	160	5	20				20			17	25					10	18	4	17
Hortman series:																				
Hortman fine sandy loam, 2 to 4 percent slopes	80	200	8	30			8	30									20	40	4	15
Hortman-Axtell fine sandy loams, 4 to 10 percent slopes	80	200	8	25				25					1	2		2	20	30	4	19

See footnotes at end of table.

TABLE 7.—*Estimated average acre yields of principal crops that may be expected over a period of years on the soils of McLennan County, Tex., under two levels of management*—Continued

Soil	Cotton lint		Corn		Oats		Grain sorghums		Wheat		Peanuts		Sorgo		Alfalfa		Pasture		Land class	Agronomic group
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B		
	Lb.	*Lb.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Cow-acre-days* [1]	*Cow-acre-days* [1]		
Houston Black series:																				
Houston Black clay, 0 to 1 percent slopes	200	250	35	35	30	40	25	35					3	4		4	80	160	1	4
Houston Black clay, 1 to 4 percent slopes	180	250	20	35	30	40	20	35					3	4		4	75	100	1	3
Houston Black gravelly clay, 1 to 4 percent slopes	180	250	20	35	30	40	20	35					3	4		4	75	100	1	3
Houston Black clay, moderately deep variant, 1 to 4 percent slopes	160	200	15	25	35	40	15	25					2½	3½		3½	75	100	2	9
Houston series:																				
Houston clay, 1 to 4 percent slopes	180	250	20	35	30	40	20	35					3	4		4	75	100	1	3
Houston clay, 4 to 8 percent slopes	120	200	12	30	30	40	12	30					2	3		3	50	70	3	11
Houston clay, 8 to 15 percent slopes																	50	60	(2)	21
Irving series:																				
Irving clay loam, 0 to 1 percent slopes	160	225	15	30	30	40	15	30					2½	3½		3½	40	70	2	8
Irving clay loam, 1 to 3 percent slopes	160	225	15	30	30	40	15	30					2½	3½		3½	40	70	2	7
Irving silt loam, 0 to 1 percent slopes	140	225	12	25	25	35	15	25					2	3		3	40	60	2	8
Irving-Axtell complex, 0 to 1 percent slopes	120	225	12	25	25	30	15	25					2	3		3	30	50	2	8
Ivanhoe series:																				
Ivanhoe-Irving-Axtell complex, 0 to 1 percent slopes	175	225	15	30	30	35	15	30					2½	3½		3½	40	70	2	8
Kaufman series:																				
Kaufman clay loam, 0 to 1 percent slopes	150	200	25	35			25	35					3	4		4	50	180	3	14
Kaufman loam, 0 to 1 percent slopes	150	200	25	35			25	35					3	4		4	50	180	3	14
Krum series:																				
Krum clay, 4 to 8 percent slopes	150	200	15	30	30	40	15	30					2	3½		3½	90	120	3	11
Lewisville series:																				
Lewisville clay, 0–1 percent slopes	200	250	25	40	35	50	25	40	17	20			3	4		4	80	160	1	5
Lewisville clay, 1 to 4 percent slopes	200	250	25	40	35	50	25	40	15	20			3	4		4	80	160	1	5
Lewisville clay, 4 to 8 percent slopes	120	200	12	30	30	40	12	30	14	20			2	3		3	50	70	3	11
Lewisville clay loam, 1 to 4 percent slopes	180	250	20	35	35	50	20	35	15	20			3	4		4	75	100	1	5
Lewisville clay loam, 4 to 8 percent slopes	120	200	12	30	25	40	12	30	12	18			2	3		3	50	70	3	11
Milam series:																				
Milam fine sandy loam, 1 to 4 percent slopes	100	200	12	30				30			27	40	1½	2½		2½	30	60	3	13
Milam fine sandy loam, 4 to 8 percent slopes	80	200	8	30			8	30			20	30	1	2		2	15	40	4	19
Milam loamy fine sand, 1 to 4 percent slopes	80	200	8	30				30			25	40	1	1½		1½	10	20	4	17

Miller series:																				
Miller clay, 0 to 1 percent slopes	225	350	30	40	----	----	35	40	----	----	----	----	4	4	4	4	70	180	1	2
Norge series:																				
Norge clay loam, 1 to 4 percent slopes	180	250	20	35	30	40	20	35	----	20	----	----	3	4	----	4	75	100	1	5
Norge fine sandy loam, 1 to 4 percent slopes	140	250	18	35	----	----	----	35	----	----	----	----	2	3	----	3	60	140	1	6
Norwood series:																				
Norwood silt loam, 0 to 1 percent slopes	250	400	35	50	----	----	35	50	----	----	----	----	4	4	4	4	60	180	1	1
Norwood silty clay loam, 0 to 1 percent slopes	250	400	35	45	----	----	35	45	----	----	----	----	4	4	4	4	70	180	1	1
Patrick series:																				
Patrick clay, 1 to 4 percent slopes	160	200	15	25	35	40	15	25	----	----	----	----	2½	3½	----	3½	75	100	2	9
Patrick gravelly clay, 2 to 15 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	30	35	(2)	21
Payne series:																				
Payne clay loam, 1 to 2 percent slopes	160	225	15	30	30	45	15	30	----	----	----	----	2½	3½	----	3½	40	70	2	7
Pledger series:																				
Pledger clay, 0 to 1 percent slopes	150	200	22	30	----	----	22	30	----	----	----	----	3	4	----	4	50	180	3	14
Riesel series:																				
Riesel-Axtell gravelly loams, 1 to 4 percent slopes	80	200	8	30	----	----	10	30	----	----	----	----	1½	2	----	2	20	30	4	15
Riesel-Axtell gravelly loams, 4 to 8 percent slopes	70	175	6	20	12	----	----	20	----	----	----	----	1	2	----	2	20	30	4	19
Riesel-Irving gravelly clay loams, 1 to 4 percent slopes	160	225	15	30	30	40	15	30	----	----	----	----	2½	3	----	3	40	70	2	7
Riesel-Irving gravelly clay loams, 4 to 8 percent slopes	120	200	10	30	25	40	12	30	----	----	----	----	----	----	----	----	40	50	3	11
Riverwash	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0	0	(2)	23
Rough broken land	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	10	10	(2)	23
Rough stony land, Brackett soil material	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	10	15	(2)	23
San Saba series:																				
San Saba clay, 0 to 2 percent slopes	200	250	25	35	35	50	30	35	17	20	----	----	3	4	----	4	80	160	1	4
San Saba clay, shallow variant, 0 to 1 percent slopes	160	200	15	30	35	40	15	30	----	----	----	----	2½	3	----	3	75	100	2	9
San Saba-Crawford stony clays, 1 to 2 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	50	60	(2)	21
Sawyer series:																				
Sawyer fine sandy loam, 0 to 1 percent slopes	100	200	12	30	----	----	----	30	----	----	30	40	1½	2½	----	2½	30	60	3	13
Stidham series:																				
Stidham loamy fine sand, 0 to 2 percent slopes	80	200	8	30	----	----	----	30	----	----	25	40	1	2	----	2	10	20	4	17
Sumter series:																				
Sumter clay, 8 to 20 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	20	30	(2)	21
Tarrant series:																				
Tarrant stony clay, 1 to 8 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	25	30	(2)	21
Tarrant-Brackett stony clays, 8 to 20 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	20	20	(2)	21

See footnotes at end of table.

TABLE 7.—*Estimated average acre yields of principal crops that may be expected over a period of years on the soils of McLennan County, Tex., under two levels of management*—Continued

Soil	Cotton lint		Corn		Oats		Grain sorghums		Wheat		Peanuts		Sorgo		Alfalfa		Pasture		Land class	Agronomic group
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B		
	Lb.	*Lb.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Cow-acre-days* [1]	*Cow-acre-days* [1]		
Travis series:																				
Travis fine sandy loam, 1 to 4 percent slopes	100	200	12	35	.....	.....	.....	35	.....	.....	25	35	1½	2½	.....	2½	35	60	3	13
Travis fine sandy loam, 4 to 8 percent slopes	80	200	8	30	.....	.....	8	30	.....	.....	.....	.....	1	2	.....	2	15	30	4	19
Trinity series:																				
Trinity clay, 0 to 1 percent slopes	150	200	22	35	.....	.....	22	35	.....	.....	.....	.....	3	4	.....	4	50	180	3	14
Vanoss series:																				
Vanoss fine sandy loam, 0 to 1 percent slopes	140	250	18	40	.....	.....	.....	40	.....	.....	30	45	2	3	.....	3	.....	140	1	6
Vanoss silt loam, 0 to 1 percent slopes	190	275	25	40	30	40	25	40	.....	.....	.....	.....	3	4	.....	4	.....	140	1	6
Wilson series:																				
Wilson clay loam, 0 to 1 percent slopes	170	225	15	30	30	40	18	30	.....	.....	.....	.....	2½	3½	.....	3½	.....	70	2	8
Wilson clay loam, 1 to 3 percent slopes	160	225	15	30	30	40	15	30	.....	.....	.....	.....	2½	3½	.....	3½	40	70	2	7
Wilson-Houston complex, 3 to 8 percent slopes	120	200	12	30	30	40	12	30	.....	.....	.....	.....	1½	2½	.....	2½	40	50	4	20
Wilson-Houston complex, 8 to 15 percent slopes	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	50	50	(2)	21
Yahola series:																				
Yahola silt loam, 0 to 1 percent slopes	160	200	20	30	30	.....	20	30	.....	.....	.....	.....	2½	4	2½	4	100	100	2	10
Yahola very fine sandy loam, 0 to 1 percent slopes	100	150	10	17	.....	.....	.....	17	.....	.....	50	45	.....	.....	.....	.....	50	90	4	18

[1] Cow-acre-days, used to express the carrying capacity of pasture, is the product of the number of animal units carried per acre multiplied by the number of days that animals can be grazed without injury to pasture; for example, a soil that supports 1 animal unit per acre for 360 days rates 360; a soil supporting 1 animal unit on 2 acres for 180 days rates 90; and a soil supporting 1 animal unit for 100 days on 4 acres rates 25. An animal unit is the equivalent of 1 mature cow, steer, or horse, 5 hogs, or 7 sheep or goats.

[2] Nonarable.

MORPHOLOGY AND GENESIS OF SOILS

McLennan County lies in the Blackland and Grand Prairies of Texas—the most southerly extension of the prairies of central United States. The climate is warm, continental, and transitional humid-subhumid. The soils of the county are largely dark-colored limy clays (Grumusols, formerly called Rendzinas) formed under tall grasses on marl, chalk, or calcareous clay. Reddish Prairie Soils are developed on some of the harder limestones. Planosols developed under prairie vegetation make up considerable areas; and there are some areas of Red-Yellow Podzolic Soils that developed under oak-savannah vegetation.

Table 8 shows the relationships of parent material, drainage, and soil series in the principal catenas in McLennan County.

The county is underlain by marine sediments of the Cretaceous system. This system is represented in the county by two series—the Gulf, which is of unconsolidated or weakly consolidated formations and underlies the Blackland Prairie, and the Comanche, which is of limestone with some subsidiary marl and underlies the Grand Prairie. The formations dip gently to the east and give rise to a succession of north-south outcrop belts, most of which are occupied by characteristic associations, or catenas, of soils. From east to west, corresponding to descent in the geological column, the succession of outcropping formations is as follows: Taylor group, mainly of highly calcareous clay but including some sandy clay and chalk; Austin chalk; Eagle Ford, mainly of calcareous shale but including a friable marl and some flagstone near the middle; Washita group of limestones and subsidiary marls; and Edwards limestone of the Fredericksburg group.[9] The first three are of the Gulf series; the last two, of the Comanche. For purposes of soil classification the boundary between the Blackland Prairie and Grand Prairie is placed at the eastern limit of limestone. Since the uppermost Comanche formation is a marl, this limit is a short distance west of the Comanche-Gulf contact.

Stream terraces are extensive and form three principal levels above the present flood plains. The highest terraces occupy stream divides and are classed by geologists as of Pliocene or early Pleistocene age. They are smoothly dissected; little or none of their constructional surface remains; and their soil development is as advanced as that in any part of the county. The largest areas are near Gholson School and Ross on divides between the Brazos River, Aquilla Creek, and Tehuacana Creek; smaller areas are near China Spring on the Brazos-Bosque divide and near Axtell and Riesel. In all of the areas save that near China Spring, the sediments are mixtures of quartzitic gravel, sand, and clay. The one near China Spring is underlain by calcareous friable earth and limestone gravel.

The middle terraces lie 50 to 100 feet above the present flood plains and are largely undissected. They are high and, for the most part, slowly drained flats that occur along all the larger streams. On middle terraces along the Brazos River, the sediments are calcareous

[9] SELLARDS, E. H., ADKINS, W. S., and PLUMMER, F. B. THE GEOLOGY OF TEXAS. Vol. 1, STRATIGRAPHY. Tex. Univ. Bul. 3232, 1007 pp., illus. 1932.

TABLE 8.—*Relationships of parent material, drainage, and soil series in the principal catenas in McLennan County, Tex.*

Parent material	Surface drainage			
	Very slow to none	Slow to medium	Medium to rapid	Very rapid
Highly calcareous impervious clay:				
Marine	Houston Black	Houston Black	Houston	Sumter.
Alluvial	Bell	Bell		
Friable permeable marl or chalk:				
Marine	Houston Black	Houston Black	Austin	Eddy.
Alluvial	Bell	Lewisville	Lewisville	
Moderately calcareous slowly permeable clays:				
Prairie:				
Marine, heavy	Burleson or Wilson	Burleson-Houston or Wilson.	Houston	Sumter.
	Wilson	Crockett	Crockett	
Alluvial, heavy	Burleson	Burleson-Houston	Houston	
Alluvial, moderately sandy or gravelly.	Irving	Riesel	Riesel	
Oak savannah:				
Alluvial, sandy	Irving[1]	Axtell	Hortman	
Permeable sandy clays or silts, alluvial:				
Youthful terraces	Brewer	Vanoss	Bastrop	Bastrop.
Old terraces:				
Moderately sandy	Irving[1]	Sawyer and Milam	Milam and Travis	Milam and Travis.
Very sandy	Eufaula	Eufaula	Eufaula	Eufaula.
Earthy limestone	San Saba	Denton	Tarrant	Brackett.
Hard limestone	San Saba	Crawford	Tarrant	Tarrant.
			Tarrant	
Calcareous alluvial clays or gravel with rapidly permeable substrata.	Irving	Payne	Norge	
	Bell	Lewisville	Patrick	Patrick.

[1] Glady forest or savannah.

sands and silts with considerable limestone gravel. Along streams that drain the Grand Prairie, they are permeable highly calcareous clays with much associated limestone gravel. Along streams draining the Blackland Prairie, they are heavy calcareous clays of slow permeability. Where the sediments are sandy, the areas are forested and are occupied by light-colored Planosols or Red-Yellow Podzolic Soils.

The low terraces are undissected benches of the Brazos River that lie less than 50 feet above its flood plain. They are sufficiently recent that soil development is less advanced than on older surfaces. The characteristic association of soils developed on the sandier and siltier sediments is Bastrop-Vanoss-Brewer; the corresponding catena developed on similar materials in older surfaces is Milam-Sawyer-Irving.

REPRESENTATIVE PROFILES

Profiles of new soil series established in McLennan County are described below. If "moist" is not specified, color descriptions refer to dry soils. These profiles have distinctive characteristics representative of soils that occur in this and similar areas of comparable geologic, vegetative, and climatic environment.

AXTELL SERIES

The Axtell soils are Planosols, that is, soils in an advanced stage of development. Associated with these soils in the catena are the Hortman, which are more rapidly drained and have redder less mottled upper subsoils. Axtell soils are somewhat less acid than the Leaf soils of Mississippi and other more humid areas, which they resemble to some degree. They have developed from calcareous or alkaline clays high in montmorillonite rather than from acid parent materials. The parent materials generally are of old alluvium that contains some waterworn siliceous gravel toward the base.

The following profile of Axtell very fine sandy loam occurs on a very high old terrace of the Brazos River 2 miles southwest of Axtell in the eastern part of the county. The areas are nearly level to gently sloping and are under a natural scrub forest of blackjack and post oaks. Runoff is slow and internal drainage is very slow; the soil is droughty and of low fertility.

Soil profile (Axtell very fine sandy loam):

A_1 0 to 3 inches, grayish-brown (10YR 5/2; 4/2, moist) very fine sandy loam; hard when dry, very friable when moist; very weakly granular to massive; slightly acid; 2 to 4 inches thick.

A_2 3 to 6 inches, light-gray (10YR 6.5/1; 4/1.5, moist) very fine sandy loam; hard when dry, very friable when moist; massive but moderately permeable; rests abruptly on the underlying claypan; medium acid; 3 to 6 inches thick.

B_2 6 to 15 inches, reddish-brown (5YR 4/3; 4/4, moist) clay or heavy sandy clay mottled with grayish brown and yellowish brown; mottling increases with depth so that, in the lower half, no one color is dominant; very firm and compact when moist, very hard when dry; weak medium blocky with pronounced clay skins, which make the outsides of peds dark grayish brown; very slowly permeable; plant roots abound both within and between aggregates; grades to horizon below; strongly acid; 8 to 15 inches thick.

B_3 15 to 40 inches, light olive-gray (5Y 6/2; 5/3, moist) sandy clay mottled with light brownish gray and brown; very firm and compact but slightly less so than horizon above; weak coarse prismatic; acid above but becoming alkaline below; noncalcareous; 18 to 30 inches thick.

C_1 40 to 60 inches, light olive-gray (5Y 6/2) and light yellowish-brown (2.5Y 6/4) weakly calcareous compact clay or sandy clay; 15 to 30 inches thick.

C_2 60 to 90 inches +, like horizon above but mildly to strongly calcareous.

BRAZOS SERIES

The characteristics of the Brazos series are represented by the following profile observed 6 miles north of Waco on a low terrace of the Brazos River a few feet above ordinary overflow. Shallow inundations occur on Brazos soils for short periods when overflows are exceptionally high, but they are infrequent enough to allow a weak color profile development. These soils are closely related to Reinach soils and occupy similar positions; they differ, however, in having more sandy subsoils.

Soil profile (Brazos silt loam):

A_1 0 to 20 inches, brown (7.5YR 4/3; 3/3, moist) silt loam; very friable; moderate medium granular; the lower part is reddish brown; neutral; layer ranges in thickness from 12 to 25 inches.

C_2 20 to 50 inches +, light reddish-brown (5YR 6/4; 5/4, moist) loamy very fine sand weakly stratified with thin seams of silt and fine sand; calcareous.

Range in characteristics: Color of the surface soil brown to reddish brown (hues 5YR and 7.5YR, values 4 and 5, chromas 2 to 4); colors least dark in the sandiest types; reaction of surface soil, calcareous to neutral; texture of subsoil, sand to loamy very fine sand.

EDDY SERIES

Eddy soils are light brownish-gray strongly calcareous Lithosols. They overlie slightly weathered chalk or chalky marl. They occur in association with soils of the Austin and Houston Black series in the Blackland Prairie section of the county. Eddy soils are similar to Austin but are lighter colored, low to only moderate in fertility, and generally unsuited to cultivation. The following profile, from a moderately sloping cultivated area 4 miles west of Eddy, is representative of the series.

Soil profile (Eddy gravelly clay loam):

1. 0 to 5 inches, light brownish-gray (2.5Y 6/2; 5/2, moist) gravelly clay loam; strong medium granular; very crumbly and friable when moist, slightly hard when dry; gravel consists of chalk fragments and makes up 20 to 30 percent of the soil volume; very strongly calcareous; layer ranges from 3 to 10 inches in thickness.
2. 5 to 30 inches +, soft or semi-indurated white chalk or chalk fragments; soft chalky marl over indurated chalk.

Range in characteristics: Color ranges from light gray to grayish brown; virgin areas, as a rule, are distinctly browner than cultivated areas; a 2 to 4 inch transition layer of light-gray soft chalky marl occurs over the chalk in places; angular fragments of chalk are up to 3 inches in diameter and make up as much as 50 percent of the soil volume where erosion is severe; nongravelly types, mainly silty clay, are recognized.

HORTMAN SERIES

The Hortman are moderately well drained, light-colored, Red-Yellow Podzolic soils. They were developed on high stream terraces from old alluvium deposited along rivers that carry sediments originating partly or wholly in grasslands underlain by redbeds. Hortman soils in this area are associated with the Stidham, which has a yellowish friable subsoil; the Eufaula, which consists of deep fine sands; and the Axtell which have mottled claypan subsoils. A representative profile of Hortman fine sandy loam, 2 to 4 percent slopes, as observed 8 miles north of Waco, 1 mile southwest of Elm Mott is described below. The area is gently sloping and is forested with scrub forest of blackjack and post oak.

Soil profile (Hortman fine sandy loam):

A_1 0 to 3 inches; dark grayish-brown (10YR 4/2; 3/2, moist) fine sandy loam; weakly granular; very friable; neutral; layer ranges in thickness from 3 to 5 inches.

A_2 3 to 8 inches, pale-brown (10YR 6/3; 5/3, moist) fine sandy loam; structureless; very friable; slightly acid; ranges from 3 to 9 inches in thickness.

B_2 8 to 15 inches, red (2.5YR 4/8; 3/8, moist) clay; moderate medium blocky; firm; very hard when dry; slightly acid; ranges from 5 to 15 inches in thickness.

B_3 15 to 35 inches, mottled red (2.5YR 5/6) and pale-yellow (2.5Y 7/4) clay; medium blocky; very firm; very sticky and plastic when wet; slightly acid; ranges from 15 to 25 inches in thickness.

C_1 35 to 60 inches, mottled yellow (2.5Y 7/6) and light-gray (2.5Y 7/2) compact sandy clay with a few red mottlings; weakly stratified with reddish-yellow sandy loam in the lower part; slightly acid to neutral; ranges from 20 to 40 inches in thickness.

C 60 to 70 inches +, old alluvium of reddish sandy clay somewhat stratified with thin sandy and silty layers; neutral to calcareous; usually contains pockets or lenses of clay and scattered concretions of $CaCO_3$.

Range in characteristics: Sandy loams are the principal types; color in A_1 horizon ranges from dark grayish brown to brown, in A_2 from brown to very pale brown, in B_2 from reddish brown to red or yellowish red, and in B_3 from red with slight pale-yellow mottling to mottled yellow and light gray with slight red mottling; depth to alkaline or calcareous parent material varies from 3 to 12 feet.

KRUM SERIES

The Krum series consists of dark grayish-brown, calcareous, very granular soils developed in old alluvial fans and narrow valleys in humid limestone prairies such as the Grand Prairie of Texas. The parent material is of light-brown or yellowish-brown, highly calcareous, friable slope alluvium washed from higher slopes of Denton, Tarrant, and Brackett soils. The following profile of Krum clay is representative of the series. This profile occurs in a moderately sloping shallow valley (gradient 5 percent) 7 miles southeast of Valley Mills, which is just over the line in Bosque County. The area is a prairie pasture that has never been plowed; vegetation is mainly little bluestem and grama grasses; surface drainage is medium to rapid. Considerable runoff water comes from surrounding more sloping shallow stony soils and slowly and continually adds fresh soil material to the surface in this area.

Soil profile (Krum clay):

A_{11} 0 to 10 inches, very dark grayish-brown (10YR 3/2; 2/2, moist) clay or silty clay; strong medium granular; friable; strongly calcareous; layer ranges from 8 to 15 inches in thickness.

A_{12} 10 to 25 inches, dark grayish-brown (10YR 4/2; 3/2, moist) light clay or silty clay; strong medium granular; very crumbly and friable; strongly calcareous; ranges from 12 to 20 inches in thickness.

AC 25 to 50 inches, brown (10YR 5/3; 4/3, moist) silty clay of same structure, consistence, and reaction as horizon above; ranges in thickness from 20 to 30 inches.

C 50 to 70 inches +, yellowish-brown (10YR 5/6, same, moist) strongly calcareous silty clay; contains scattered subrounded fragments of limestone and some soft concretions of $CaCO_3$; permeable; commonly underlain at depths of 3 to 10 feet by substratum of marine limestone or marl.

Range in characteristics: Color of the A_{11} horizon ranges from very dark grayish brown to dark brown, and the A_{12} from dark grayish brown to yellowish brown; clay is the principal type but clay loams also occur; a few small particles of $CaCO_3$ may occur in all horizons.

NORGE SERIES

The Norge series consists of Reddish Prairie soils. There are two types in McLennan County, fine sandy loam and clay loam. Norge soils have more clayey subsoils than Vanoss, Bastrop, or Milam, and darker surface soils than Travis, all of which have developed in association under transitional forest-grasslands from more or less similar parent materials. The profile of Norge fine sandy loam, given below, is representative of an area near Alta Vista School south of Waco. The parent materials are alkaline to calcareous old stream sediments; the soil apparently has developed under a grass cover.

Soil profile (Norge fine sandy loam):

A 0 to 12 inches, reddish-brown (5YR 4/4; 3/4, moist) fine sandy loam; weakly granular; friable; about neutral; layer ranges from 8 to 14 inches in thickness.

B_2 12 to 38 inches, red (2.5YR 4/6; 3.5/6, moist) sandy clay; massive to very weak blocky; firm; very hard when dry; medium acid; ranges from 20 to 30 inches in thickness.

B_3 38 to 60 inches, yellowish-red (5YR 5/8; same color, moist) sandy clay; massive; porous; friable; very hard when dry; about neutral; ranges from 15 to 30 inches in thickness.

C 60 to 100 inches +, reddish-yellow (5YR 6/8) friable sandy earths of more or less stratified sandy clay and sandy loam; weakly calcareous; a few small concretions of $CaCO_3$.

Range in characteristics: Types range from fine sandy loam to clay loam; color of the A horizon ranges from brown to reddish brown, and of B_2 horizon from yellowish red to red, encompassing values of 4 to 5, hues of 2.5YR to 7.5YR, and chromas of 6 to 8; reaction of A horizon ranges from medium to slightly acid, and of B_3 horizon, from slightly acid to weakly alkaline; a few waterworn pebbles of quartz or quartzite usually occur in all horizons.

PATRICK SERIES

The Patrick soils are dark, calcareous, clayey intrazonal soils without texture profiles and very shallow to moderately deep over limestone gravel. They are associated with and related to Lewisville soils, from which they differ mainly in having porous beds of gravel within a depth of 3 feet. They occur in the zone of Reddish Prairie soils on terraces of streams that carry sediments derived largely from

limestone prairies. The following profile of Patrick clay is representative of the series as developed in McLennon County. The area is 9 miles west of Waco on gently sloping old stream terraces with a gradient of 3 percent. The vegetation is native little bluestem and gramagrasses.

Soil profile (Patrick clay):

A_1 0 to 14 inches, very dark grayish-brown (10YR 3/2; same color, moist) light clay; strong medium granular; crumbly and friable; calcareous; layer ranges from 10 to 20 inches in thickness.

AC 14 to 30 inches, brown (10YR 4/3; 3/2, moist) clay or silty clay; strong medium granular; very crumbly and friable; hard when dry; strongly calcareous; contains a few rounded particles of hard $CaCO_3$; rests on horizon below; ranges from 3 to 24 inches in thickness.

Cu 30 to 50 inches +, a porous bed of waterworn limestone gravel containing a small amount of yellowish-brown fine earth; very weakly to strongly cemented in the top part with calcium carbonate.

Range in characteristics: Clays and gravelly clays are predominant but some clay loams occur; color of A_1 horizon ranges from very dark brown to dark yellowish brown; thickness of solum ranges from 18 to 36 inches in the clay type and 5 to 18 inches in the gravelly type.

PAYNE SERIES

The Payne series consists of dark grayish-brown noncalcareous soils that developed on old high river terraces in the prairies of Texas. Payne soils have well-developed profiles and apparently are intermediate between normal Reddish Prairie soils and Planosols. Only one type of the series was encountered in McLennan County, Payne clay loam. It is associated with Irving soils, which are dark-gray planosolic Reddish Prairie soils; and with Lewisville and Patrick soils, which are calcareous clayey soils, without texture profiles, that were formerly classed as Rendzinas. The following profile of Payne clay loam, observed in a cultivated field that was originally prairie, has characteristics representative of the series. It is well drained and has a gradient of 1 percent.

Soil profile (Payne clay loam):

A_1 0 to 8 inches, dark grayish-brown (10YR 4/2; 3/2, moist) clay loam; weakly granular; friable; surface of cultivated fields crusts on drying; neutral to slightly acid; passes abruptly to horizon below; layer ranges from 5 to 10 inches in thickness.

B_{21} 8 to 20 inches, dark-brown (7.5YR 3/4; same color, moist) clay; weakly blocky, the upper 3 or 4 inches being weak coarse granular; very firm; very sticky and stiff; neutral to slightly alkaline; ranges from 8 to 16 inches in thickness.

B_{22} 20 to 30 inches, brown (7.5YR 4/4; same color, moist) clay; weak coarse blocky; firm; calcareous; grades into horizon below; ranges from 7 to 15 inches in thickness.

B_3 30 to 45 inches, like horizon above but faintly mottled with yellowish red and light brown; strongly calcareous; ranges from 10 to 20 inches in thickness.

C 45 to 80 inches +, light yellowish-brown (10YR 6/5) strongly calcareous friable clay containing scattered concretions of $CaCO_3$

Range in characteristics: Clay loam is the principal type; color of the A_1 horizon ranges from dark grayish brown to brown; the crusted surface in cultivated fields is light brownish gray to depth of 1 inch; reaction, slightly acid to slightly alkaline; depth to calcareous material generally ranges from 25 to 40 inches; where depth is less than 20 inches, the subsoil is less blocky and more friable.

TARRANT SERIES

The Tarrant soils are dark-colored Lithosols on limestone. They occur within the zones of Reddish Prairie and Reddish Chestnut soils. The series is very extensive in the Grand Prairie, where it is associated with the related Denton and Brackett soils. A representative profile of Tarrant stony clay, from a gently sloping area (gradient 2 percent) 5 miles northwest of Crawford is given below. The vegetation is native mixed tall and short grasses, but mainly little bluestem.

Soil profile (Tarrant stony clay):

A_1 0 to 5 inches, very dark grayish-brown (10YR 3/2; 2/2, moist) clay; strong fine or medium granular; very crumbly and friable; strongly calcareous; contains small fragments of limestone; layer ranges from 2 to 8 inches in thickness.

AD_r 5 to 12 inches, broken or partly weathered limestone containing a small amount of brown clay in crevices and between fragments; layer ranges from 2 to 10 inches in thickness.

D_r 12 inches +, limestone bedrock.

Range in characteristics: Depth to limestone never exceeds 12 inches; in many places the parent rock is interbedded limestone and marl; color of the A_1 horizon varies from very dark brown to grayish brown, the hue ranging from 7.5YR to 2.5Y, the value from 2 to 5, and the chroma from 1.5 to 3; the principal type is stony clay, but the stony loam and nonstony types may occur; in local areas, generally of smooth relief, the soil material is noncalcareous.

ENGINEERING APPLICATIONS[10]

This soil survey report for McLennan County, Tex., contains information that can be used by engineers for the following purposes:

(1) For soil and land-use studies that will aid in the selection and development of industrial, business, residential, and recreation sites.

(2) For estimates of runoff and erosion characteristics of terrain units for use in designing drainage structures and planning dams and other structures for water and soil conservation.

(3) For reconnaissance surveys of soil and ground conditions for highway and airport locations and for planning the detailed soil surveys on the designed locations.

(4) For locating sand and gravel for use in structures.

(5) For correlating pavement performance with types of soil and thus developing information that will be useful in designing and maintaining the pavements.

(6) For determining the suitability of soil units for cross-country movements of vehicles and construction equipment.

(7) For use, along with other published maps and reports and aerial photographs, in making soil maps and reports that can be readily used by engineers.

Engineers who are unfamiliar with the pedologic terminology and the procedure used in making the pedologic survey should refer to the section, Soil Survey Methods and Definitions.

Some of the engineering information can be obtained from the soil map, but reference to the text of the report, particularly the sec-

[10] This section was prepared by the Physical Research Branch, Bureau of Public Roads. Test data in table 9 were obtained in the Soils Laboratory in the Bureau of Public Roads.

tion, Descriptions of the Soils, will often be necessary. A general idea regarding the engineering characteristics of major map units can be obtained by reference to the section, Principal Soil Areas and Their Use.

Representative soil samples from some of the principal soil series were tested to help evaluate the soils for engineering purposes. The test data are given in table 9. Although each of the five soil types tested were sampled in three different localities, the test data probably do not represent the maximum range in physical test characteristics for each type.

The soils of McLennan County are derived from a variety of consolidated and unconsolidated parent materials. These materials occupy topography in various stages of dissection. Because of this wide variation in materials and topography, many engineering problems arise. The following discussion is confined to use of the soil survey information in highway construction.

The moderately to highly plastic residual soils, such as the Austin, Houston, and Wilson, which are derived from chalk, marl, or marine clays, and the alluvial soils washed from these materials, such as the Burleson and Trinity, have caused poor pavement performance. If these soils are too wet when the pavement is constructed, subsequent drying will cause shrinkage of the soil under the edges of the pavement, and longitudinal cracking of the pavement may occur. If they are too dry, subsequent absorption of moisture by the soil under the outer edge of the pavement causes sufficient volume change in the soil to warp the pavement. To control detrimental shrinkage and swelling in embankments, these highly plastic soils should be compacted to at least the maximum density, at or slightly above the optimum moisture content, as determined in the standard American Association of State Highway Officials compaction test.

It has been observed that deep-rooted vegetation reduces the percentage of moisture content in these highly plastic soils several points below that of nonvegetated soils or that of soils with light vegetation. Where these dry bulbs of soil exist in the soil profile at the time a pavement is constructed, wetting of the soil causes swelling, and a wavy pavement surface results. When the soil below grade in cut sections, or the undisturbed soil beneath proposed fills, is too dry, it is usually not economically feasible to scarify and recompact the soil at the proper moisture content and density to more than a slight depth. Hence, other methods of moisture control are recommended. To permit absorption and retention of rainwater by the soil, the vegetation should be removed from the road right-of-way several months before paving is begun. Where the soil has been dried to a considerable depth because of the action of vegetation, it has been recommended [11] that an extensive survey be made to determine the limits of the dried soil, and that water be ponded on these sections for a considerable period before construction of the pavement. The ponding is effective when the soil structure will permit comparatively rapid absorption. However, it is not effective if the

[11] FELT, E. J. INFLUENCE OF SOIL VOLUME CHANGE AND VEGETATION ON HIGHWAY ENGINEERING. The 26th Annual Highway Conference of the University of Colorado; pp. 52–76, illus. 1953.

TABLE 9.—*Engineering test data for samples*

Soil name and location	Parent material	Bureau of Public Roads report number	Depth	Horizon	Mechanical analysis [2] Percentage passing sieve— 2 in.	1½ in.	1 in.	¾ in.	⅜ in.
			Inches						
Austin silty clay—4.75 miles SW. of traffic circle in south Waco, along U. S. Highway 81.	Chalk interbedded with marl.	91392	0–30	A_1 and A_{12}.	.....	.....	.....	.....	.....
		91393	46–72	C.....	.....	.....	.....	.....	.....
Austin silty clay—14.8 miles SSW. of traffic circle in south Waco, along U. S. Highway 81.	Chalk.....	91400	0–15	A_{11}.....	.....	.....	.....	.....	.....
		91401	36–46	C_2.....	100	74	61	51	40
Austin silty clay—6.8 miles SW. of traffic circle in south Waco, along U. S. Highway 81.	Chalk.....	91414	0–24	A_1.....	.....	.....	.....	.....	.....
		91415	50–66	C_2.....	.....	.....	.....	.....	.....
Denton clay—3 miles SW. of U. S. Highway 84 intersection at west side of McGregor.	Limestone....	91394	0–15	A_1.....	.....	.....	.....	.....	.....
		91395	15–30	A_{12}.....	.....	.....	.....	.....	.....
Denton clay—3.75 miles S. of U. S. Highway 84 intersection at west side of McGregor.	Limestone....	91396	0–14	A_{11}.....	.....	.....	.....	.....	.....
		91397	14–29	A_{12} and AC.	.....	.....	.....	.....	.....
Denton clay—4.2 miles S. of U. S. Highway 84 intersection at west side of McGregor.	Limestone....	91398	0–12	A_1.....	.....	.....	.....	.....	.....
		91399	12–24	A_{12}.....	.....	.....	.....	.....	.....
Houston Black clay—2 miles SW. of Rosenthal, 3 miles W. of Golindo.	Calcareous marine clay.	91402	0–44	A_{11} and A_{12}.	.....	.....	.....	.....	.....
		91403	84–120	C_2.....	.....	.....	.....	.....	.....
Houston Black clay—2.25 miles WSW. of Robinson.	Calcareous marine clay or marl.	91404	0–50	A_{11} and A_{12}.	.....	.....	.....	.....	.....
		91405	66–108	C_2.....	.....	100	98	91	72
Houston Black clay—½ mile SE. of Tours.	Marl.....	91412	0–34	A_{11} and A_{12}.	.....	.....	.....	.....	.....
		91413	66–84	C_2.....	.....	.....	.....	.....	.....
Trinity clay—1.8 mile NE. of Concord.	Recent alluvium.	91386	0–36	.....	.....	.....	.....	.....	.....
Trinity clay—1 mile SE. of Leroy.	Recent alluvium.	91390	0–36	.....	.....	.....	.....	.....	.....
Trinity clay—1.1 mile ESE. of Leroy.	Recent alluvium.	91391	0–36	.....	.....	.....	.....	.....	.....
Wilson clay loam—1.6 mile N. of Concord.	Compact calcareous clay of old stream terraces.	91387	0–8	A_1.....	.....	.....	.....	.....	.....
		91388	8–42	B_2.....	.....	.....	.....	.....	.....
		91389	58–80	C_2.....	.....	.....	.....	.....	.....
Wilson clay loam—4.6 miles NNE. of Elm Mott.	Compact calcareous marine clay.	91406	0–10	A_1.....	.....	.....	.....	.....	.....
		91407	10–46	B_2.....	.....	.....	.....	.....	.....
		91408	84–120	C_2.....	.....	.....	.....	.....	.....
Wilson clay loam—2.4 miles SW. of Leroy.	Compact calcareous marine clay.	91409	0–7	A_1.....	.....	.....	.....	.....	.....
		91410	7–34	B_2.....	.....	.....	.....	.....	.....
		91411	58–84	C_2.....	.....	.....	.....	.....	.....

[1] Tests performed by Bureau of Public Roads in accordance with standard procedures of the American Association of State Highway Officials.

[2] According to the American Association of State Highway Officials designation T 88, results by this procedure frequently may differ somewhat from results that would have been obtained by the Soil Conservation Service soil survey procedure. According to the AASHO procedure, the fine material is determined by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material including that coarser than 2 mm. in diameter; whereas, according to the SCS soil survey procedure, the fine material is determined by the pipette method and the material coarser than 2 mm. in diameter is excluded from calculations of grain-size fractions.

from 15 soil profiles,[1] *McLennan County, Tex.*

Mechanical analysis [2]—Continued										Liquid limit	Plasticity index	Moisture-density		Classification
Percentage passing sieve—Con.					Percentage smaller than—									
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.050 mm.	0.020 mm.	0.005 mm.	0.002 mm.	0.001 mm.			Maximum dry density	Optimum moisture	
												Lb. per cu. ft.	*Per-cent*	
-------	-------	-------	100	99	97	88	70	51	40	69	42	99	21	A-7-6 (20)
-------	-------	-------	100	99	98	92	75	51	39	59	38	111	17	A-7-6 (20)
-------	100	99	98	94	90	80	66	51	39	59	31	95	25	A-7-6 (20)
34	30	23	22	20	20	17	12	7	4	35	14	116	15	A-2-6 (0)
-------	100	99	99	98	97	90	69	53	43	66	36	97	22	A-7-5 (20)
-------	-------	-------	100	98	97	88	68	47	33	51	31	111	17	A-7-6 (18)
-------	-------	100	99	96	92	80	61	54	50	73	40	90	27	A-7-5 (20)
-------	100	98	97	94	90	79	62	52	47	69	41	96	23	A-7-6 (20)
-------	100	98	97	94	90	78	63	55	49	67	37	92	26	A-7-5 (20)
-------	100	97	96	93	89	78	61	47	39	60	34	102	20	A-7-6 (20)
-------	100	98	97	94	90	77	61	55	51	69	37	94	25	A-7-5 (20)
-------	100	97	96	93	89	79	63	54	47	70	40	93	27	A-7-5 (20)
-------	100	99	97	93	91	82	63	55	52	76	45	96	24	A-7-5 (20)
-------	100	99	99	98	98	97	80	57	43	69	47	101	21	A-7-6 (20)
-------	100	99	99	98	97	92	81	72	69	104	63	86	31	A-7-5 (20)
55	42	42	42	42	41	39	32	22	16	69	46	107	20	A-7-6 (7)
-------	100	98	96	88	83	69	53	46	45	65	34	97	23	A-7-5 (20)
-------	-------	-------	100	99	99	96	80	64	54	83	53	100	23	A-7-5 (20)
-------	-------	-------	100	96	92	79	57	48	45	67	39	98	21	A-7-6 (20)
-------	-------	-------	100	95	88	73	56	49	44	63	37	100	21	A-7-6 (20)
-------	-------	100	99	96	94	85	65	55	50	83	52	98	24	A-7-5 (20)
-------	100	99	98	87	79	60	38	32	30	43	23	105	18	A-7-6 (14)
-------	100	99	98	90	84	64	43	36	32	47	26	104	18	A-7-6 (16)
-------	100	99	99	87	74	56	38	32	30	45	27	114	16	A-7-6 (16)
-------	-------	100	99	96	90	69	41	32	30	48	25	99	21	A-7-6 (16)
-------	100	98	95	83	75	55	40	34	31	52	33	106	18	A-7-6 (18)
-------	100	97	93	78	66	47	30	26	25	44	26	113	15	A-7-6 (15)
-------	100	98	94	76	65	49	33	26	22	37	21	112	16	A-6 (12)
-------	100	98	94	79	73	59	43	37	32	50	31	108	17	A-7-6 (18)
-------	100	96	92	77	70	56	39	33	31	47	29	114	15	A-7-6 (17)

soil is disturbed or the soil structure does not permit the water to be readily absorbed.

The warping of pavements caused by wetting or drying of the plastic soil will be minimized if a blanket course of soil having low volume change is used beneath the pavement.

Some of the residual soils, such as the Crawford, Ellis, San Saba, and the shallow variant of the Denton series, are moderately to highly plastic but have such a shallow profile that warping of pavements on the undisturbed soil is not a problem. The primary problem in these soil units, or at the transition to the adjacent units, may be that of locating the highway so as to avoid excessive rock excavation.

Some of the terrace soils, such as the Bell, contain moderate to highly plastic clay in the upper part of the profile but may contain lenses or thin strata of granular material at a depth of a few feet. An extensive soil survey along the highway location will be warranted in areas of these soils, in order that the granular material may be used in the upper part of the subgrade.

The soil map shows gravel or other pits in the following soils: Austin, Axtell, Bastrop, Bell, Catalpa, Crawford, Crockett, Denton, Houston, Lewisville, Milam, Patrick, Payne, Sawyer, Stidham, Tarrant, and Travis, and in the Hortman-Axtell, Ivanhoe-Irving-Axtell, Riesel-Axtell, Riesel-Irving, and Wilson-Houston complexes. However, the natural material in some pits is unsuitable for use in base and surface courses of highway pavements. In some pits, the quality of the material is poor; in others, processing will produce material with a suitable gradation.

The fact that several gravel pits, some of which are extensive, are located in areas of the Lewisville and Patrick soils indicates that these soils are generally the best sources of gravel in the county. The gravel in these soils is derived from limestone. The clay overburden on the gravel is usually less than 2 feet thick in the Patrick soils. In areas where the Lewisville soils contain gravel beds, the clay overburden is usually more than 30 inches thick. There are large pits in the Bastrop and Stidham soils near Waco, but usually sand is predominant in these soils.

On many designed highway locations, major soil variations may occur within the depth of proposed excavation and several soil units may be encountered within a short distance. The soil map and profile descriptions should be used in planning the detailed soil survey to be made on the designed highway location. The use of such information will enable the soils engineer to concentrate his efforts on some soil units and obtain a minimum of soil samples for testing in the laboratory. He can thus make an adequate highway soil survey at minimum cost.

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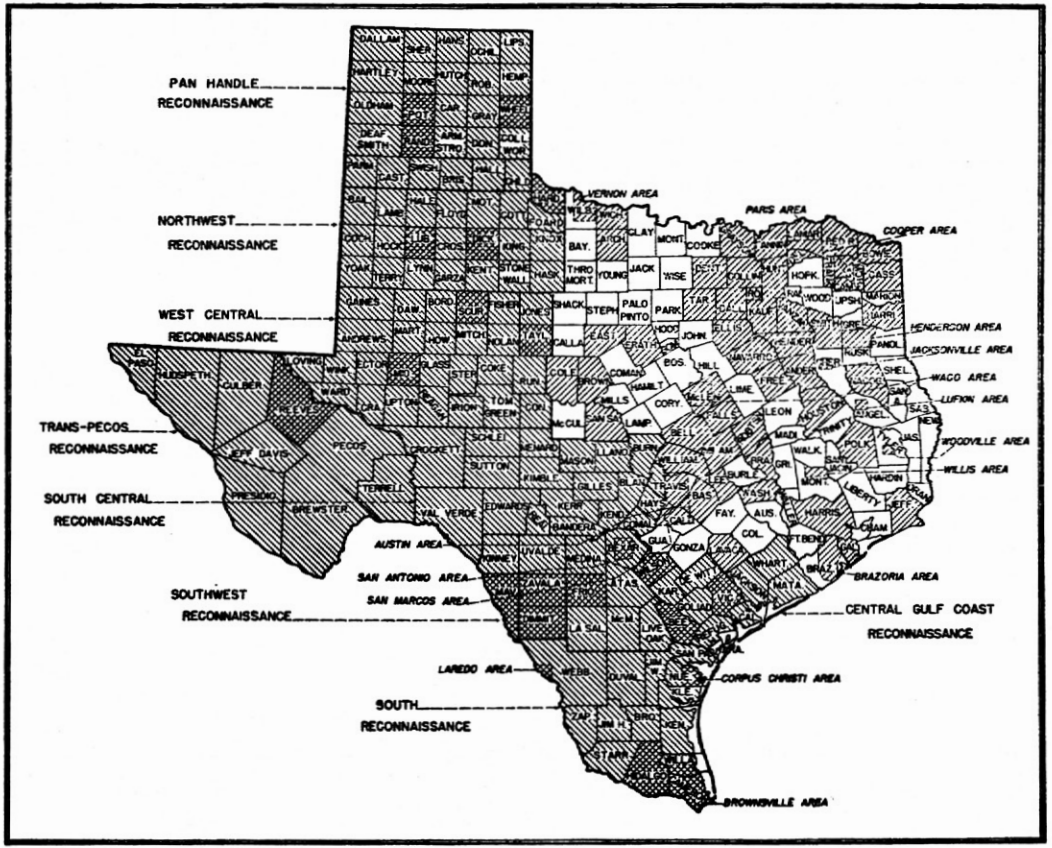

Areas surveyed in Texas shown by shading. Detailed surveys shown by northeast-southwest hatching; reconnaissance surveys by northwest-southeast hatching; crosshatching indicates areas covered both ways.

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