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Soil Survey
of
Frio County, Texas

By

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and
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Texas Agricultural Experiment Station

Bureau of Chemistry and Soils
In cooperation with the
Texas Agricultural Experiment Station

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SOIL SURVEY OF FRIO COUNTY, TEXAS

By M. W. BECK, United States Department of Agriculture, in Charge, and H. W. HAWKER and L. G. RAGSDALE, Texas Agricultural Experiment Station

COUNTY SURVEYED

Frio County is in that part of southern Texas (fig. 1) commonly referred to as southwest Texas. Pearsall, the county seat, is about 50 miles southwest of San Antonio, about 90 miles east of the Mexican boundary, and 130 miles northwest of the Gulf coast. The east-west dimension of the county, which is rectangular in shape, is about 37 miles, and the north-south dimension is 30½ miles. The total area is 1,124 square miles, or 719,360 acres.

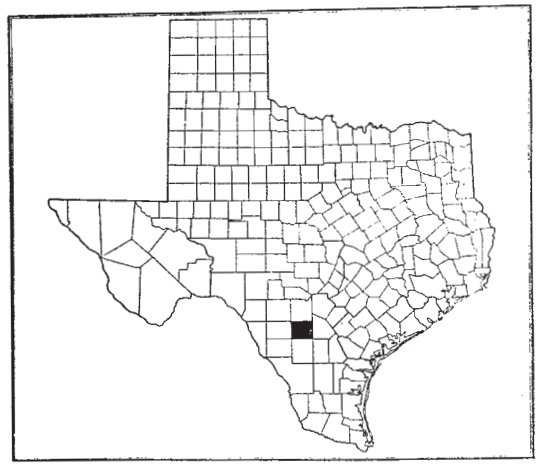

FIGURE 1.—Sketch map showing location of Frio County, Tex.

Physiographically, Frio County consists of a rolling plain dissected by numerous streams that have cut shallow and comparatively narrow valleys. Much of the surface is nearly flat or gently undulating, with many low hills and ridges having long smooth gentle slopes, except in the southwestern part. The most prominent hills are Marshall Hills, 6 miles north of Orelia; English Hills, 8 miles northwest of Divot; and Pilot Knob, the highest point in the county and a distinct landmark, 11 miles west of Pearsall. These hills rise from 75 to more than 100 feet above the surrounding plains. Southeast of Pearsall a chain of small domelike hills capped with ferruginous sandstone fragments rises from 25 to 50 feet above the general land surface. A few of these hills comprise narrow ridges with steep slopes. The streams of this county, most of which are intermittent, occupy shallow channels lying within narrow flat strips of flood plain.

The average elevation of Frio County is about 600 feet above sea level. Pilot Knob has an elevation of about 725 feet. The elevation at Pearsall on the general plain is 646 feet; at Moore is 650 feet; and at Dilley is 586 feet.[1] Probably the lowest point is where Frio River leaves the county at an elevation of about 400 feet.

[1] GANNETT, H. A DICTIONARY OF ALTITUDES IN THE UNITED STATES. U.S. Geol. Survey Bul. 274, Ed. 4, 1,072 p. 1906.

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According to local information, the sandy soils were covered with a dense growth of sedge grass, with a very sparse growth of small mesquite trees, until about 1890. After this time, probably largely owing to prairie fires and rather heavy pasturing, the sedge grass became less abundant and the small tree and brushy growth increased. The gravelly and stony hills have always been covered with a dense shrub growth, mainly of black chaparral and huajillo. According to reports of early settlers, the bottom lands were largely open grasslands with some mottes (groves) of live oak and hackberry trees.

At present, the land, where not cultivated, supports a growth of brushy vegetation and small trees. The sandy soils in many places have a scattered growth of mesquite trees with a dense brushy growth of huisache, granjeno, lote bush, pricklypear, catclaw, black chaparral, and huajillo. In the more open places needle grass, crowfoot, and grama grasses abound. The dark soils are partly occupied by small mesquite trees and dense brushy clumps of pricklypear, guyacan, lote bush, granjeno, huisache, and white brush. The principal grass growth comprises several species of grama, though in the lower-lying and less brushy areas buffalo and mesquite grasses predominate, with some needle grass and other grasses. The higher-lying Victoria soils have a scattered growth of mesquite trees and some short grasses and grama grasses. The gravelly and stony hills are covered mostly by brushy thickets of huajillo and black chaparral, with some pricklypear, sagebrush, Jatropha, lote bush, granjeno, and a few small mesquite trees, together with a very sparse growth of needle grass. The stream-bottom lands are covered in places with a heavy growth of hackberry, elm, and live oak trees and in other places by mesquite trees and a dense undergrowth of white brush, huisache, and granjeno. The open areas of bottom land are covered with buffalo, mesquite, and other grasses. The deep sandy soils in the northern part of the county have an open growth of small trees, mainly live oak, blackjack oak, hickory, and in places some scattered small mesquite trees, and an undergrowth of some of the coarser grasses.

Frio County was organized in 1870, and the county seat was established at Frio Town, the point of first settlement. In 1883, Pearsall became the county seat. The first settlement in the country now included in Frio County was made about 1860 by people from Kentucky, Tennessee, some other Southern States, and the eastern part of Texas. A rather large proportion of the present population consists of Mexicans, many of them native born.

According to the 1930 census, the population of Frio County is 9,411, or about 8.4 persons a square mile, an increase of only 1.2 percent over the preceding 10-year period. Although 73.1 percent of the population is classed as rural, many of the people live in villages and small towns. Of the rural population, 5,348 are classed as rural farm, and 1,527 as rural nonfarm. Nearly all parts of the county are very thinly settled. Pearsall, the county seat and principal town, has a population of 2,536, which is the entire urban population. Dilley and Moore are smaller towns and shipping points on the railroad, and Bigfoot, Miguel, Schattel, Divot, Orelia, and Frio Town are villages and trading centers located in different parts of the county away from the railroad.

The Missouri Pacific Railroad, supplemented with bus and truck service, furnishes transportation facilities. The San Antonio-Laredo

paved highway (United States Highway 81) passes through the central part of the county. The other roads are not surfaced, but most of them are graded and maintained in good condition, except in wet weather. Telephone service is adequate in most parts, although some distant ranches do not have this service. A small proportion of the county is served by rural delivery of mail.

CLIMATE

The climate of Frio County is subhumid. The winters are rather short, and the prevailing temperature is moderate. The mean monthly temperature ranges from 52.3° F. in January to 86.1° in August, a difference of 33.8°. Extreme temperatures recorded are 14° in January and 110° in August, but such extremes are rare.

Early settlers report that on February 21, 1899, the temperature was as low as 4°. The mean temperature for the winter months is 54.9° and for the summer months is 85.1°. The summers are rather long and and hot, but the heat, especially at night, is tempered considerably by breezes from the Gulf. The mean annual relative humidity is low.

Owing to the mild winter climate, the region is locally known as the "winter garden." Spinach, strawberries, and Bermuda onions are produced under irrigation during the winter. Spinach is produced in some years without irrigation, and early fall and early spring vegetables are produced under irrigation. For several years, small plantings of citrus fruits have been successfully grown. One seedling grapefruit tree in Pearsall is 28 years old. On January 2, 1928, the temperature dropped to 16° and killed many young trees and injured others, but many of the older trees produced a fair crop that year. The production of citrus fruits on a commercial scale seems possible where the trees are properly cared for.

The average date of the earliest killing frost is December 4, and that of the latest, February 23. This gives a normal frost-free season of 284 days, sufficient time to mature successively both a truck crop and a cotton crop on the same land. Frosts have been recorded as early as October 30 and as late as March 20.

The mean annual precipitation of 20.52 inches is not sufficient for maximum yields, and crop failures, particularly of corn, are not uncommon when the rainfall alone is depended on for moisture. Irrigation from shallow wells and from artesian wells insures crop production and allows a wider range of crop diversification.

Southerly extensions of storms reach this country as sudden cold north winds, locally called "northers", which as a rule last but a few days. The prevailing winds are from the southeast, and in early spring they are sometimes of high velocity, though not destructive. According to local information, hailstorms are rather unusual.

Onions and spinach have been successfully produced during the winter for a number of years. Peaches do not thrive, but plums, grapes, figs, pecans, and strawberries are grown successfully. Some Persian (English) walnuts have been planted, to test their suitability for this section.

The low rainfall has influenced the development of certain distinctive soil characteristics, the most outstanding of which is the presence of a horizon of calcium-carbonate accumulation in some part of the normal soil profile.

Table 1 is compiled from the records of the Weather Bureau station at Dilley, in the southern part of the county, lying at an elevation of 586 feet.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Dilley, Frio County, Tex.*

[Elevation, 586 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1917)	Total amount for the wettest year (1919)
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*
December	54.1	86	20	1.26	0.00	0.82
January	52.3	89	14	.77	.00	3.02
February	58.3	97	20	1.08	[1]	1.71
Winter	54.9	97	14	3.11	[1]	5.55
March	64.0	98	26	1.85	.19	2.24
April	71.6	101	45	1.84	.00	3.78
May	77.8	105	46	3.12	.25	2.89
Spring	71.1	105	26	6.81	.44	8.91
June	83.5	109	52	2.02	[1]	7.01
July	85.7	109	70	1.38	3.10	3.75
August	86.1	110	69	1.34	[1]	2.05
Summer	85.1	110	52	4.74	3.10	12.81
September	81.6	102	52	2.67	1.62	5.43
October	73.3	96	32	1.88	.00	5.24
November	61.8	92	32	1.31	.80	1.12
Fall	72.2	102	32	5.86	2.42	11.79
Year	70.8	110	14	20.52	5.96	39.06

[1] Trace.

AGRICULTURE

Prior to the Civil War, the general region in which Frio County lies was a vast open cattle range utilized by ranchers who owned or controlled large landholdings. Cattle and horses were raised in large numbers, and, before the advent of railroads, large herds of cattle were driven overland to distant markets each year. As early as 1860, small settlements, mainly ranch headquarters, and trading centers, were located along some of the streams where access to water and wood was easy, and small acreages o land were cultivated by some farmers to provide corn and vegetables for home use. At one time, sheep raising became locally important, but low prices caused this industry to decline, and since 1883 little of the range land of Frio County has been used for sheep. With the advent of barbed wire in the seventies, large blocks of range land were fenced, improved breeds of beef cattle were gradually introduced, and small amounts of some feed crops were grown to augment the range forage for some of the more valuable range livestock. Since 1919, some of the more brushy gravelly land has been successfully used for an important goat-raising industry, and the production of mohair, from high-grade Angora goats, has been an important industry in recent years.

Farming in Texas was gradually extended westward into Frio County as fencing became possible. Owing to the uncertain moisture conditions, dry farming has always been uncertain, but since 1905 some farmers have attained a more certain degree of success by irrigation from streams and from shallow wells. Originally only such general-farm crops as cotton, corn, sorghums, and other feed crops were grown, but since the advent of irrigation, together with the advantages of a mild winter climate, many farmers have engaged partly or wholly in specialized truck growing, and, to some extent, they are advancing cautiously into the growing of fruits. Thus it may be seen Frio County constitutes a part of a large section of Texas which is very slowly undergoing a transition from a ranching to a farming country.

The larger proportion of the land is still used for grazing range livestock, on both large and small ranches. Well-improved grade beef cattle, largely of Hereford blood, comprise the herds on the larger ranches. Much of the ranch land is devoted to the grazing of beef steers, owing, it is said locally, to the increased brushy growth on the range, which makes the land less suitable for breeding cattle than formerly.

According to the census of 1930,[2] there are 943 farms in the county, nearly half of which are between 50 and 175 acres in size. The farms listed as comprising more than 500 acres, of which there are 170, doubtless are ranch holdings given over entirely to range livestock. About 15 percent of the total land area of the county, an average of about 117 acres to the farm, is devoted to the production of farm crops.

Table 2, giving the acreage and production of the leading crops, as reported by the census, shows the general trend of agriculture in Frio County in the last 50 years.

TABLE 2.—*Acreage and production of principal crops in Frio County, Tex., in stated years*

Crop	1879		1889		1899		1909		1919		1929	
	Acres	*Bales*	*Acres*	*Bales*	*Acres*	*Bales*	*Acres*	*Bales*	*Acres*	*Bales*	*Acres*	*Bales*
Cotton	543	156	3,088	1,473	13,764	2,616	52,057	6,822	55,349	4,308	52,018	3,533
		Bush.		*Bush.*		*Bush.*		*Bush.*		*Bush.*		*Bush.*
Corn	1,574	7,443	2,772	48,592	5,600	61,960	2,708	12,531	14,757	295,504	[1] 17,262	242,787
Kafir and milo							415	3,678	453	11,554	287	4,245
Potatoes		112	1	25	5	320			11	286	7	406
Sweetpotatoes	27	1,578	21	1,925	3	115			207	12,937	5	205
Other vegetables							330		762		2,379	
		Tons		*Tons*		*Tons*		*Tons*		*Tons*		*Tons*
All hay	16	44	125	171	490	837	290	187	1,044	935	233	259
Coarse forage					3,606	5,705	3,619	2,754	9,572	12,434	[2] 8,056	[2] 8,752

[1] In addition to the corn harvested for grain, that from 55 acres was cut for fodder and that from 250 acres was hogged or grazed off.

[2] Largely grain sorghums harvested with grain remaining on stalk and fed locally in this form.

Since 1899, the chief crop has been cotton, the acreage increasing rapidly to about 1924, when 73,333 acres were devoted to this crop. Since that time, the acreage has decreased to about 50,000 acres. The acreage devoted to commercial truck crops has increased from 762 acres in 1919 to 2,379 acres in 1929, and in addition 358 farms

[2] Soil-survey reports are dated as of the year in which the field work was completed. Later census figures are given when available.

reported vegetables grown only for home use. The principal vegetables and truck crops are beans, peas, spinach, onions, tomatoes, squash, carrots, cantaloups, and watermelons.

The 1930 census reports 273 acres devoted to orchards and subtropical fruits, vineyards, and planted nut trees. The following numbers of fruit and nut trees are reported in the county: Apricots, 1,279; figs, 583; peaches, 4,406; pears, 282; plums and prunes, 10,330; grapefruit, 2,267; oranges, 7,005; and 3,952 pecan trees. Many of these trees have not yet reached bearing age. In addition to the fruit and nut trees, there are 7,910 grapevines.

Of the 27,939 cattle reported in 1930, 2,703 cows were used for milk production. Whole milk sold amounted to 144,952 gallons in 1929, and 34,939 pounds of cream were sold as butterfat. Most of the cattle are range beef cattle, of which 8,871 head are steers more than 2 years old. On April 1, 1930, there were 4,906 head of swine, 32,136 chickens, 2,289 horses, 3,549 mules, 1,573 sheep, and 16,796 goats.

The value of crops produced in Frio County in 1929, as given by the census, was $849,117, of which the value of vegetables, potatoes, sweetpotatoes, fruits, and nuts totaled $64,194. The total value of livestock in 1930 was $1,707,118, of which the value of cattle amounted to $1,211,283.

A small quantity of commercial fertilizer is used by some truck growers for vegetables and watermelons. According to the 1930 census, $9,201 was spent for fertilizer, including 184 tons of commercial fertilizers, on 55 farms in 1929. All the fertilizer is purchased ready mixed. The principal mixture used in Frio County is a 6:10:7,[3] and it is used on different crops. Spinach is usually fertilized with nitrate of soda only.

Most of the farm laborers are Mexicans, and the supply is usually sufficient. Day laborers are paid from $1 to $1.50. Harvesting of crops—such as cotton, spinach, and onions—is performed mainly on a contract basis. Monthly laborers are paid from $25 to $40, with house furnished.

There has been a general increase in the number of small farms. The irrigated farms range in size from 5 to 150 acres, and most of the unirrigated farms include about 160 acres. Ranches range from 1,000 to 65,000 acres in extent, averaging about 5,000 acres. In 1930 the average size of farms was 593.6 acres, owing probably to the subdivision of large ranch landholdings into smaller units. Only 290 farms include less than 100 acres.

The 1930 census reports 26.7 percent of the farms operated by owners, 1.5 percent by managers, and 71.8 percent by tenants. Farm land is leased on a share basis and livestock range land on a cash basis. Tenants on the share basis usually operate on the "third-and-fourth" system; that is, the tenant delivers one fourth of the cotton and one third of all other crops to the owner for the use of the land and farm buildings. The tenant furnishes all labor and expense connected with growing the crops. Some farms are leased on the half-and-half plan, by which the owner furnishes work animals, implements, and seed, and receives one half of all crops. Range land on livestock ranches leases for 25 to 50 cents an acre, depending on the improvements, water supply, and value of the natural range forage.

[3] Percentages, respectively, of nitrogen, phosphoric acid, and potash.

The farm improvements are fair in most parts of the county. Many good houses and fair outbuidings are on the farms operated by the owners, but, as a rule, the buildings on the tenant-operated farms are small and poor. Modern machinery and implements are in general use. The work animals are good mules and horses of medium weight. Tractors are used on many farms. The beef cattle are predominantly high-grade Herefords, and the dairy cows are grade and purebred Jerseys and Holsteins.

Located near the western limit of successful dry farming, Frio County, particularly the western part, is still given over largely to raising and grazing range livestock. General farming comprises an important industry, though it is confined more especially to the soils occurring in advantageous locations, which have characteristics enabling crop production under the uncertain moisture supply of a subhumid climatic section. Truck growing is important in some localities where irrigation water is available, and certain fruits, including some citrus fruits, are showing promise of successful commercial production, though as yet the fruit-growing industry is in the experimental stage. Miscellaneous minor local industries consist of marketing the farm surpluses of dairy and poultry products, hogs, and honey.

The principal industry of the county has always been the raising of cattle on large ranches. The industry remains very important here, and much land is still used for this purpose. The development of general farming during the last few years has led to the opening up of much of the ranch land for crop production, and many of the ranches are gradually being subdivided into farms. Cattle are still raised in a rather large way, though the ranches are smaller and are fenced into pastures, and the industry is conducted on a much more intensive scale than formerly. Cattle raising and marketing of young calves is practiced largely in the western part of the county, but in other parts the ranching industry consists principally of grazing 1- to 4-year-old steers that have been shipped in from other sections, until the market price warrants their sale. These steers are sold as feeders on the Fort Worth and Kansas City markets, from which points they are distributed to be fattened in the corn-growing States of the central West. Very few animals are fattened locally.

The beef cattle are chiefly improved grades of Hereford breeding, though a few native Mexican steers are grazed for a time. The natural range vegetation constitutes the chief subsistence of cattle, though at times when range feed is short, an additional ration of cottonseed cake is given.

Goat raising is an important industry in some sections. The brushy lands of the gravelly and stony areas support a heavy growth of huajillo and black chaparral, which constitute valuable forage for goats, and these otherwise almost valueless lands are thus profitably utilized. Most of the goats are of Angora breeding and, from these, mohair comprises a valuable crop annually. A rather large number of native "slick-haired" goats are raised for meat, and some goat milk is used locally, chiefly among the Mexicans. The chief menaces to goat raising are predatory animals, but they are gradually being killed.

Dairying is an industry of some importance, carried on either independently or in conjunction with general farming. The native grasses afford pasture most of the year, though some farmers grow sudan

grass for summer pasture. Corn and grain sorghums are grown for grain feeds and for other forage. Among the dairy herds, Jersey and Holstein are the principal breeds, and some of the herds are made up of purebred cattle. Milk and cream are shipped by truck to San Antonio, and some cream is shipped to creameries outside the State.

Hogs and poultry are raised on most farms and the surplus products are sold for shipment.

Cotton is the chief cultivated crop, except where truck crops are grown in conjunction with general farming or on farms devoted entirely to such crops. Cotton gins are located throughout the county, in localities convenient to the farming communities, and from these the baled cotton lint is hauled to railroad points for sale or shipment. All the cotton is shipped to the seaports for export to markets in various parts of the world. A cotton-seed oil factory is located at Pearsall.

Grain sorghums, mostly kafir, milo, feterita, and hegari, are grown largely on all farms for feed for the farm livestock. Very little of the grain is harvested separately, but the stalk is cut with the grain on it, and the fodder and grain are fed together. Other forage comprises sorgo (sweet sorghum), cut as coarse fodder, and sudan grass for summer pasture. Corn is grown mainly for grain. Some broomcorn is grown and shipped to points outside the county.

Some farmers and ranchers market large quantities of honey. Many of the native shrubs and small plants, chiefly huajillo and white brush, are especially suited for honey production. The honey is of very fine quality and flavor and finds a ready sale.

Truck crops are grown mainly for winter and spring markets, and these products are shipped to different market centers of the United States, though some are sold locally and in San Antonio. Truck crops are produced either on farms in conjunction with the general-farm crops or on farms devoted entirely to this branch of agriculture. Most of these crops are grown with irrigation from wells, when the rainfall is insufficient. In the order of their value as marketed in 1929, truck crops rank as follows: Watermelons, onions, tomatoes, peas, spinach, and beans. Many other vegetables are grown, but to less extent than those named. With the mild winter climate, large areas of excellent truck soils, and possibility for irrigation from wells, the production of truck crops can be greatly extended.

Although fruit growing has as yet attained no important status, many farms include small orchards that supply home requirements to some extent, but most of the fruit trees planted are not yet (1929) of bearing age. Large areas of soils are well suited to fruit growing with irrigation, and the chief drawback is the uncertainty of the climate. An occasional late freeze in some years occurs at such a time as to damage the crop. The chief fruits planted are peaches, plums, figs, and apricots. These and grapes grow well, and their acreage is increasing. Fruit growing, doubtless, will be gradually extended, and by using means of protection from occasional freezes the possibilities seem encouraging.

In preparing the land for cotton and corn, the general practice is to "bed" the land with a "middle buster" in the fall or winter. On some farms the land is bedded in the spring by turning the former water furrow into a ridge or bed and leaving the furrow in the former bed. This method is a quick way of preparing the land, but better

results are obtained where the land is plowed early in the fall before bedding. Cotton and corn are both planted in the water furrow. Cotton is planted from March 1 to May 1, with March 20 about the average date, and harvesting begins about July 20. Corn is planted from January 20 to March 15, with the average date about February 25. All corn is consumed on the farm, and the cotton is sold as a cash crop.

The land for hegari and other grain sorghums is bedded in the same manner as that for cotton and corn, and these crops are planted in the water furrow. The grain sorghums are usually seeded at a rate ranging from 3 to 5 pounds to the acre. It has been discovered that early planting of hegari is undesirable, and the best dates for planting this crop are from April 1 to April 20 for the summer crop and from August 1 to September 1 for a fall crop. Hegari and other grain sorghums are entirely consumed on the farm.

The best results with sudan grass have been obtained by flat breaking the land and drilling the seed in 3-foot rows. Broadcasting the seed, which makes cultivation impossible, does not give satisfactory yields unless moisture conditions are right. Sudan grass is used for pasture and is seldom cut for hay. The best planting date for this crop is about March 20.

Under dry-land farming practices, it has been found that all crops should be grown in rows, in order to allow cultivation. Spinach and sudan grass have been broadcast, but returns have been unsatisfactory.

Land for spinach is flat broken early in the fall. Dry-land spinach is sown in rows 3 feet apart. On irrigated land, spinach is sown broadcast. It is planted from October 1 to November 15 and harvested from December 10 to March 20. The common practice is to use from 100 to 300 pounds of nitrate of soda an acre for spinach. During the season of 1927–28, one farmer increased his yield 54 bushels by using 200 pounds of nitrate of soda, and 92 bushels by using 300 pounds, over a yield of 390 bushels produced by using 150 pounds of nitrate of soda. It is common practice to apply a light application of nitrate of soda at the time of seeding and the remainder in about 30 days. Irrigation water is applied at intervals ranging from 10 to 15 days.

Onion seed is planted in the seed bed between September 10 and September 15, and the best dates for transplanting onions to the field are from November 20 to December 1. The land is flat broken early in the fall, and the onions are planted on a slight ridge. They are set in 15-inch rows, from 4 to 6 inches apart in the row. A 6:10:7 fertilizer is used for onions at a rate ranging from 300 to 500 pounds an acre, with good results. Good clean cultivation is necessary at all times in the production of this crop. Onions are watered immediately after planting and afterward at intervals ranging from 10 to 15 days.

Watermelons are usually grown on the deep sandy lands. The common practice is to flat break the land. A deep furrow is plowed out, and 200 pounds an acre of 6:10:7 fertilizer is applied in the furrow where the hills are to be made. The furrow is then plowed shut, forming a slight bed. Watermelons are planted in rows 12 feet apart each way. Clean cultivation is practiced at intervals ranging from 10 to 15 days. The seed is planted from February 15 to March 1, and the melons are harvested from June 10 to July 15.

No systematic crop rotation is generally practiced.

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SOILS AND CROPS

Many different soils occur in Frio County. Texturally, they range from fine sand to clay, but the fine sandy loams and clay loams predominate.

Considered as to use, the soils may be separated into two divisions—one including the deep soils with smooth surface relief and the other comprising shallow stony or gravelly soils suited only for pasture. Very large bodies of the deep agricultural soils, members of the first group, occur in most parts of the county, but the largest areas are in the southwestern part. These soils occupy more than half the land area. On the whole, they are deep; have thick subsoil layers; and are readily penetrated by water, air, and plant roots. They range considerably in suitability for different kinds of crops and in their productive capacity. Regardless of how fertile they may be, their productivity is limited by the moisture supply, and the irregular and often scanty rainfall of this climatic region causes much variation in crop yields. Therefore, in dry farming, the soils best suited for crops are those which have characteristics and features enabling the collection and retention of soil moisture. Farming has been carried on sufficiently long in Frio County to make possible the determination of the soil-crop adaptations and of the relative soil-production capacities. Although more or less land of the better agricultural soils has been used for the many crops that can be grown in the section, the dry-farming operations have now become fairly definitely centered around such drought-resistant crops as cotton and grain sorghums grown on the soils having the most favorable soil-moisture relationships. These crops are moderately deep rooted and require a large quantity of water for highest production, but they have the inherent ability to withstand long periods of dry weather, during which growth is arrested, and when rains come vigorous growth is resumed and yields are produced in proportion to the available supply of soil moisture.

The better soils have been found to respond well to irrigation, and where the soils lie favorably for the application of water and where irrigation water can be obtained from shallow wells, a number of farmers insure crop production by the use of available water. This has led to the more specialized production of truck crops, largely produced in conjunction with the general farm crops, and the possibilities of the increase of this industry and of some fruit growing is engaging the interest of many farmers. The long growing season and mild climate allow the production of many kinds of farm crops, truck crops, and fruits, and, with a supply of irrigation water such as can be obtained in wells in many locations, a more certain production of crops can be assured in many parts of the county.

Owing to the common recognition of differences between upland soils and alluvial soils, these soils are treated in two separate groups in this discussion, though such a simple discrimination does not afford a basis for exact soil classification as will be shown in the more technical treatment of the soils of the area in another part of this report.

The upland soils differ from one another in various characteristics and in degree of agricultural value. On the basis of their suitability for crops, they belong to two divisions—one including soils well suited to cultivated farm crops and the other comprising stony, gravelly, or shallow soils valued only for the natural vegetation that is useful for pasture for livestock.

The good agricultural upland soils, on the basis of color, fall naturally into three subgroups as follows: Red sandy soils, light-colored soils, and dark-colored soils. The soils of low agricultural value are of two general kinds—thin droughty soils and gravelly or stony soils. The alluvial soils, practically all of which are highly valuable in agriculture, include types of several soil series.

Only about 15 percent of the total land area of the county is devoted to farm crops, and the remainder is used as pasture for livestock. As a rule, only the better upland soils are used for farm crops, largely because they are readily cleared, easily cultivated, and favorably located with reference to transportation facilities. In many places these soils are very conveniently situated for the practice of irrigation.

Cotton, corn, and sorghum are grown under dry-farming practices and occupy most of the farm acreage; the acreage percentages being cotton 65 percent, corn 20 percent, and grain sorghums 10 percent of the land devoted to general farming. Vegetables and various truck crops grown for market in many small fields, either independently or in conjunction with general farming, and largely grown under irrigation, include mainly watermelons, onions, peas, spinach, tomatoes, and beans, in order of the acreage occupied by them in 1929. On many farms a very small acreage of land is devoted to many other vegetables, fruits, and berries, the 1930 census showing that 273 acres on 113 farms of the county were devoted to orchard and subtropical fruits, vineyards, and planted nut trees in 1929. Of the fruits, though many trees and vines are not yet of bearing age, those which give promise of best success are grapes, plums, apricots, peaches, figs, grapefruit, and oranges.

Of the soils used for general farming and for special truck crops and fruits, the red sandy soils and the light-colored soils are most largely utilized. They are deep and friable and are underlain by permeable subsoils containing sufficient clay to hold a large reserve of soil moisture. Though not inherently so highly productive as either the dark-colored soils or the alluvial soils, these soils are drought resistant, owing not only to the comparatively smooth surface and friable topsoils which allow ready accumulation and absorption of a large proportion of the rain water but also in part to the comparative facility with which a large proportion of soil moisture in sandy soils is available to plants. Their light texture renders these soils especially suitable for the production of many vegetables, truck crops, fruits, and berries, and the favorable moisture features, largely owing to the sandy clay subsoils, give them a high value for general farm crops.

The dark-colored soils are largely of heavy texture, of good productive capacity, and are suited to many crops which yield well when moisture is adequate. Though the surface on which they lie is in general sufficiently smooth to prevent rapid run-off of rain water, the soils absorb water slowly, requiring more extended seasons of rainfall to acquire a large reserve of soil moisture, and in dry seasons they give up water to plants more slowly than do sandy soils. They are less well suited to vegetables, other truck crops, and fruits, though cotton, corn, and sorghums, when moisture conditions are favorable, produce higher yields than on the red sandy soils or light-colored soils. The dark-colored soils are not used largely for farm crops at

present, because of their low drought resistance, the more difficult cultivation of the heavy-textured topsoils, and the narrower range of crop adaptation.

The soils of the gravelly or stony group and of the shallow group are not used for farm crops, but, together with large areas of all the other soils, are devoted to pasture for livestock. Although the grass cover is scant on these thin soils, they afford sufficient grazing, together with browse of some shrubs, to enable their profitable use for range livestock.

Most of the alluvial soils are highly productive and are well situated for collecting a large store of soil moisture. However, they are not extensively utilized for cultivated crops, probably on account of the greater cost of clearing, more difficult cultivation, and narrower range of crop adaptation of the predominating soils which are of heavy texture.

Cotton, the most important crop, has a wide range in its adaptation to soils. It does well on most of the productive soils, the yields ranging in proportion to soil productiveness and moisture conditions. The Mebane variety and strains of Mebane are largely grown, as this variety seems to have a wider range of adaptation than most others. At the Texas experiment substation no. 1, near Beeville, about 75 miles southeast of Frio County, the following varieties, grown on dark-colored soils much like those of Frio County, have given the best results: New Boykin, Sunshine (Davidson's), Harper, Lankart, Kasch, and Mebane. Most of these varieties are of the Mebane type. The staple at Beeville is of good character and ranges from fifteen sixteenths to 1 inch in length.[4]

Owing to the comparatively dry climatic conditions, injury of cotton by insect infestation is not so severe as in some more easterly sections of Texas where the rainfall is greater, but in seasons of considerable rainfall some damage is done by the bollweevil and the bollworm. Some cotton is injured and killed by cotton root-rot. Although this disease, as a rule, is more injurious on the dark-colored soils, in some years much infection of plants is noted in fields on the red sandy soils of the Duval and Webb series. The disease is more prevalent in seasons of abundant moisture than when the soil moisture is limited. However, observations made in this locality seem to indicate that root-rot is more generally prevalent on sandy soils in this relatively dry region than on sandy soils of very similar physical characteristics farther east in the humid region. Possibly the reason for this may be ascribed to the fact that the sandy soils here are less acid than similar soils in the humid region.[5]

Probably cotton is grown more on Duval fine sandy loam than on any other soil of the county, owing to ease of cultivation and to the highly desirable drought-resistant character of this soil. It is also grown on Webb fine sandy loam to a considerable extent and, under similar conditions, does almost as well as on the Duval soil. Where the dark-colored soils are farmed, the main crop, cotton, is grown mostly on Victoria clay loam and Orelia clay loam, these being the most extensive and uniform soils of the group. Yields are higher on these soils, when moisture is ample, than on the sandy soils, but,

[4] Unpublished records of the Texas Agricultural Experiment Station.

[5] TAUBENHAUS, J. J., EZEKIEL, W. N., and KILLOUGH, D. T. RELATION OF COTTON ROOT ROT AND FUSARIUM WILT TO THE ACIDITY AND ALKALINITY OF THE SOIL. Tex. Agr. Expt. Sta. Bul. 389, 19 p., illus. 1928.

owing to the lower drought resistance of the heavier soils, yields are often not high in dry seasons. Yields differ greatly according to moisture conditions, some farmers reporting a production as high as one half bale or more an acre on some sandy soils in good seasons and of 1 bale or more on some dark-colored soils and some alluvial soils under exceptionally favorable conditions. The average yield for the county in 1929, according to the census, was only about 1 bale to 14 acres, whereas in 1924 it was about 1 bale to 7 acres. This low average yield is probably caused, in part, by using some soils which are not well suited to cotton, such as soils low in available plant foods and of poor moisture-holding qualities. Only very small acreages of cotton are irrigated, though this practice has produced much higher average yields.

Corn is grown on more farms in Frio County than is cotton, according to the 1930 census, though the average acreage is only about 27 acres a farm. For high yields, corn requires a very productive soil and much moisture. The very wide distribution of corn growing in the county (on 646 farms) indicates that some is grown on soils of only moderate productiveness and that this factor and soil-moisture deficiencies are reflected by the average yield for the county, which was only about 14 bushels an acre in 1929 and 18 bushels in 1924.

Corn is grown mainly on the upland soils, though the alluvial soils seem better suited to the crop. However, the most smooth, deep, friable soils appear to give the best yields under the light rainfall, as these soils have, as a rule, the largest supply of available soil moisture. Duval fine sandy loam, where most nearly level, and the depression phases of the Duval soils are generally considered as the best suited to corn under dry-farming practices.

According to results of experiments in growing corn at Beeville on soils of the dark-colored group, it seems that early maturing varieties are most successful in this climatic region. In a 10-year period, the highest average yielding varieties were Surcropper, Thomas, and Reese Drouth Resister. These produced an average of a little more than 20 bushels an acre.[6]

Grain sorghums constitute an important crop. Grown chiefly for feeding the farm livestock, the average acreage grown on a farm, according to the census, is about 15 acres. The grain sorghums are of various kinds, including milo, kafir, feterita, and hegari. Hegari seems to be the most extensively grown at this time. Grain sorghums produce high yields of grain and fodder on the most productive soils when moisture conditions are favorable, and when moisture is deficient some growth and yields are made even under very adverse conditions. Yields of grain range from 15 to 20 bushels an acre, though they may be much higher on the better soils. Fodder yields for the county, as reported by farmers, average about 1 ton an acre. Experiments, extending over a period of 5 years, were made in growing six varieties of grain sorghums on dark-colored soils at Beeville. Early planting gave best results for most varieties, though the average yields for all, 15.6 bushels of grain and 3.14 tons of forage an acre, were obtained from the moderately early planted crop.[7] Hegari responded to late

[6] MANGELSDORF, P. C. CORN VARIETIES IN TEXAS: THEIR REGIONAL AND SEASONAL ADAPTATION. Tex. Agr. Expt. Sta. Bul. 397, 74 p., illus. 1929.

[7] KARPER, R. E., QUINBY, J. R., JONES, D. L., and DICKSON, R. E. GRAIN SORGHUM DATE-OF-PLANTING AND SPACING EXPERIMENTS. Tex. Agr. Expt. Sta. Bul. 424, 71 p., illus. 1931.

planting better than the other varieties. Hegari has become popular throughout this section because it produces good yields of grain and forage over a wide range of planting dates, thus allowing farmers to take advantage of late rains when the soil moisture of the early season is deficient.

The wide adaptation of the grain sorghums to soil and climatic conditions makes them very valuable feed crops, and doubtless their production will be increased, as feeding experiments have shown that the grain has about the same value as corn for fattening livestock.[8]

A small acreage of sorgo (sweet sorghum) is grown on some farms for forage. It grows well on all the soils, and the crop withstands droughty conditions very well. Sudan grass is a valuable forage crop which grows well on all the soils. It withstands dry conditions very well, is used for both grazing and hay, is highly valued, and probably its production will be considerably extended. Alfalfa has not been grown to a great extent, though the alluvial soils seem highly suited for its production. Some good yields have been made in small irrigated fields of Frio silty clay.

Broomcorn is grown successfully on a number of farms, and the average yield is said to be about 300 pounds an acre for the county as a whole. This crop does well on most of the smooth deep soils and withstands droughty conditions.

Vegetables, other truck crops, fruits, and berries are grown mostly on the sandy soils of the Duval, Webb, Brennan, and Nueces series. These soils are easily cultivated and respond well to irrigation. Some dark-colored soils of the Orelia and Victoria series are also used for some truck crops, but the soils of sandy texture seem to be generally more suitable than the heavy soils.

The soils described in this report are shown on the accompanying soil map. In the following discussion the descriptions of the different soils provide information enabling identification of the soils in the field, and their relationships and specific influence on agriculture are also discussed. Their distribution is shown on the accompanying soil map, and table 3 shows the acreage and proportionate extent of each soil mapped.

TABLE 3.—*Acreage and proportionate extent of soils mapped in Frio County, Tex.*

Type of soil	Acres	Per-cent	Type of soil	Acres	Per-cent
Duval fine sandy loam	137,280	19.1	Victoria fine sandy loam, light-colored phase	6,464	0.9
Duval fine sandy loam, shallow phase	2,752	.4	San Antonio clay loam	13,568	1.9
Duval fine sandy loam, deep phase	66,880	9.3	San Antonio fine sandy loam	4,608	.6
Duval fine sandy loam, depression phase	9,664	1.3	Orelia clay loam	26,560	3.7
Duval fine sand, shallow phase	8,384	1.2	Orelia fine sandy loam	6,848	1.0
Duval fine sand, depression phase	11,008	1.5	Frio silty clay	27,264	3.8
Webb fine sandy loam	64,896	9.0	Frio fine sandy loam	4,480	.6
Webb fine sandy loam, flat phase	32,576	4.5	Leona clay	2,176	.3
Neuces fine sand	12,096	1.7	Blanco silty clay loam	15,040	2.1
Brennan fine sandy loam	43,648	6.1	Webb clay loam	6,144	.9
Miguel fine sandy loam	4,800	.7	Randall clay	768	.1
Miguel fine sand, shallow phase	2,496	.3	Maverick fine sandy loam	32,000	4.4
Victoria clay loam	13,824	1.9	Maverick gravelly fine sandy loam	39,104	5.4
Victoria clay loam, light-colored phase	41,920	5.8	Webb gravelly fine sandy loam	63,168	8.8
Victoria clay	8,256	1.2	Webb stony fine sandy loam	10,688	1.5
			Total	719,360	

[8] JONES, J. M., BREWER, R. A., and DICKSON, R. E. GRAIN SORGHUMS VERSUS CORN FOR FATTENING BABY BEEVES. Tex. Agr. Expt. Sta. Bul. 296, 25 p. 1922.

UPLAND AGRICULTURAL SOILS

RED SANDY SOILS

The red sandy soils of the upland group of agricultural soils include 2 soil types and 6 phases which differ from the typical soils only in minor characteristics. The 2 soil types are Duval fine sandy loam and Webb fine sandy loam; and the 6 phases include the shallow phase and depression phase of Duval fine sand; the shallow phase, deep phase, and depression phase of Duval fine sandy loam; and the flat phase of Webb fine sandy loam. These are the characteristic red soils which occupy a very large part of many counties of the Rio Grande plain in south Texas. They are chiefly of sandy texture, noncalcareous, very productive, and suited to many crops, including truck crops and fruits. They are, where normally developed, comparatively favorable to crop production under droughty conditions. They occur in close association with one another, comprising large areas of a smoothly undulating or gently rolling plain. Only the better soils of the group are included in this division and small areas of some soils of the same series are included under other groupings on the basis of their low value for crop production.

The soils of the Duval and Webb series are similar in color and in general surface appearance, but they differ in some general physical characteristics and on this basis are further differentiated. The Duval soils are characterized by permeable subsoils which contain appreciable quantities of sand. The Webb soils differ from the Duval soils in that their subsoils are less sandy, less permeable, and in most places heavier and more dense.

Duval fine sandy loam.—Duval fine sandy loam occupies 214.5 square miles. It is the most extensive soil of the undulating sandy upland and is the most largely cultivated soil in the county. The characteristics of this soil are such as to support a widely diversified agriculture. The soil is suited to all the general-farm crops and is especially suited to vegetables, other truck crops, and fruits. The favorable soil-moisture features make the soil well suited to dry farming and also make it a very desirable soil for irrigation.

The smooth surface relief, without many steep slopes, has allowed the soil to develop deep friable surface soil and subsoil layers. As the soil has developed under a moderate growth of coarse grasses and thin-leaved shrubs, no large amount of organic matter has accumulated.

The topsoil is red or reddish-brown loamy fine sand or fine sandy loam, about 12 inches thick. Normally, the virgin soil contains only a small amount of organic matter, but under cultivation this important constituent can be readily added, which results in slightly darkening the soil material and in increasing the coherence of the mass which, owing to the large content of fine sand, is loose and friable. This layer grades through a rather thick transitional zone into a red fine sandy clay subsoil which, at a depth ranging from 2 to 3 feet, gradually changes to a yellowish-red fine sandy clay containing slightly more sand than the material just above. This layer, in turn, at a depth ranging from 3 to 4 feet, is decidedly sandy and the yellow color is predominant. To this depth the soil layers are noncalcareous, but below this the material contains much calcareous material and lumps and particles of soft white calcium carbonate are abundant. The calcareous layer, in places lying at a depth ranging from 5 to 6 feet

below the surface, ranges in thickness from 1 to 5 feet and rests on, or grades below into, less calcareous beds of hard sandy clay, or packsand, in which, in places, thin strata of sandstone occur. In the calcareous layer, the carbonate of lime, in places, occurs in layers in almost pure form, and in places where it lies near the surface it hardens to an almost rocklike mass. This material, which has accumulated during the process of soil development, is locally known as caliche. It is exposed in many cuts on slopes throughout western Texas and affords a striking feature of soil development caused by a warm climate with light rainfall.

The topsoil and subsoil of Duval fine sandy loam are very permeable and allow easy penetration of air, plant roots, and water. A very large proportion of the rain water is taken up by the soil, and there is sufficient clay in the subsoil to allow retention of a large amount of soil moisture to be held in reserve for growing crops. Chemical analyses of the soil indicate that it is rather low in nitrogen and phosphorus but moderately well supplied with the other essential plant-food materials.[9]

Although not inherently the most highly productive soil of the county, Duval fine sandy loam produces very good yields of all crops when moisture conditions are favorable, and under very dry conditions the yields are better on this soil and some of its phases than on most other soils. It is a soil suited not only to general-farm crops but to vegetables, truck crops, fruits, and berries. It is easily cultivated and is excellent for irrigation, owing to the friable and penetrable surface soil and subsoil layers and permeable substratum providing good underdrainage. It responds well to the recognized methods of soil improvement, such as the addition of organic matter and manures, the growing of legumes, and applications of certain commercial fertilizers under proper moisture conditions. Some farmers report good results obtained by using 100 pounds an acre of sodium nitrate for spinach; and for onions, 200 pounds an acre of a 6:10:7 mixture.

Crop yields average about as high as on the more productive dark-colored soils, owing to the better drought-resistant qualities of this soil. However, crops grown under dry farming suffer from lack of moisture in some seasons even on this soil, and yields range from very low to high, depending on seasonal soil moisture. If a good reserve of soil moisture has been stored prior to the growing season, crops withstand remarkably well the absence of rain for long periods, but if the season is started with inadequate soil moisture, considerable rain is required during the growing season, and frequently this does not occur.

Farmers report that with good moisture conditions cotton yields from one fourth to one half bale an acre; corn, from 25 to 35 bushels; and grain sorghums, from 20 to 40 bushels of grain. Under good moisture conditions maintained by irrigation, acre yields of onions and spinach range from 150 to 300 bushels. Other truck crops and vegetables do well. The chief truck crops grown are watermelons, onions, peas, spinach, tomatoes, and beans. The soil seems excellent for citrus-fruit trees, and the plantings of young trees are, where irrigated, growing well. The soil also produces good yields of strawber-

[9] FRAPS, G. S. THE COMPOSITION OF THE SOILS OF SOUTH TEXAS. Tex. Agr. Expt. Sta. Bul. 161, 65 p. 1913.

ries, blackberries, and dewberries. Pecan trees grow well under irrigation, the friable permeable subsoil and substratum providing an especially favorable physical soil condition required for the best growth of this valuable nut tree. Only a small number of trees have as yet been planted, and the possibilities of commercial success with the pecan on this soil have not been conclusively demonstrated.

Duval fine sandy loam, shallow phase.—The shallow phase of Duval fine sandy loam occupies rolling areas, some slopes of which are sufficiently steep to allow erosion. This soil differs from the typical soil in that the topsoil and subsoil layers are thinner and the caliche layer lies only 15 or 20 inches beneath the surface. In places, rounded chert gravel are present throughout the surface soil and subsoil. The upper part of the chalky material is hard and rocklike in many places, and at a depth ranging from 2 to 3 feet rests on the noncalcareous sandy clay or packsand comprising the parent material. Natural vegetation, especially grass, is more sparse than on the typical soil, but in places there is a rather heavy growth of shrubs.

This soil is of small extent. Owing to erosion, the thin soil is low in organic matter and seemingly also in some of the plant-food materials. The same crops are grown as on the typical soil, but the yields are much lower, this being largely owing to the droughty character of the surface soil which collects and absorbs only a small proportion of the rain water. With careful management such as terracing to prevent erosion, the soil may be greatly improved in productive ability through the well-recognized methods of soil improvement, although some time may elapse before it can be built up to the point where it may be considered as other than marginal in crop production.

Duval fine sandy loam, deep phase.—The deep phase of Duval fine sandy loam occurs in a number of large areas in the southeastern and central parts of the county. This soil occupies high, smooth, nearly flat, or gently undulating upland areas and is associated with the typical soil which, superficially, it closely resembles. It differs from the typical soil chiefly in having a thicker topsoil layer, a larger proportion of sandy material, and a less well developed layer of carbonate of lime accumulation beneath the subsoil.

This deep soil consists of reddish-brown or brownish-red loamy fine sand to a depth of about 8 inches. This material grades into red loamy fine sand which, at a depth ranging from 18 to 24 inches, grades into red fine sandy clay or fine sandy clay loam, and this, at a depth ranging from 36 to 48 inches, into yellow fine sandy clay loam. The parent material, a soft sandstone or gray packsand lies at a depth ranging from 5 to 8 feet beneath the surface. There is no well-developed layer of calcium carbonate, though in many places soft white limy concretions occur in the soil a few inches above the parent material.

The smooth surface and permeable character of this soil allow the collection of a large proportion of rain water, and erosion is not severe. The topsoil contains only a moderate supply of organic matter, and all the soil layers contain less clay than is in the corresponding layers of the typical soil. Therefore, the downward movement of water is more rapid, and leaching of the soluble plant-food constituents is more active than in the typical soil.

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Although this soil is moderately productive and the subsoil contains sufficient clay to render it fairly drought resistant, it is somewhat less productive than the typical soil and is suited to a narrower range of crops. Although only a small proportion of the land is in cultivation, a number of farms produce good yields of the general-farm and truck crops. This soil seems somewhat better suited to vegetables and other truck crops than to cotton, corn, or other general-farm crops. Farmers state that they prefer it for watermelons which yield from one half to 1 carload an acre when moisture conditions are satisfactory. The soil is excellent for many of the vine crops, such as cantaloups, cucumbers, peanuts, squash, and sweetpotatoes, also for some of the small fruits and berries.

Duval fine sandy loam, depression phase.—The depression phase of Duval fine sandy loam occurs chiefly in the southwestern part of the county in a number of long narrow swales or depressions extending through areas of the typical soil. These low areas are chiefly shallow headwater valleys through which the drainage water from higher land finds a passage to the developed drainage channels, though some areas have no outlet.

This soil differs little in characteristics from the typical soil. The topsoil is perhaps slightly darker, owing to a larger accumulation of organic matter, and the upper part of the subsoil contains less clay than the lower part. The surface soil is reddish-brown or brownish-red loamy fine sand to a depth of about 10 inches. It grades into reddish-brown fine sandy loam which, at a depth of about 30 inches, passes downward into red fine sandy clay extending several feet deeper and having a yellow shade below a depth of 3½ or 4 feet. In many places, there seems to be no well-developed layer of carbonate of lime accumulation.

This soil consists partly of local soil material washed in from adjacent slopes. There is practically no run-off of rain water, and the soil receives all the run-off water from adjacent slopes. Owing to the sandy permeable subsoil, underdrainage is favorable, and in this region of light rainfall areas of this soil are exceptionally situated to withstand droughty conditions. The soil is suited to the same crops as the typical soil, and in very dry seasons yields are in general somewhat higher. The areas of this soil are of such small size that they do not comprise whole farms but do form parts of many farms, on which the same general crops are grown as on the rest of the farm. It is stated by farmers that this is an especially desirable soil for corn which under best conditions is said to have yielded as high as 60 or 75 bushels an acre. This is probably owing not only to good moisture conditions in the soil but to the comparatively high amount of organic matter and available plant foods added by run-off waters that have leached the higher lands. Yields ranging from one fourth to 1 bale of cotton an acre have been reported.

Duval fine sand, shallow phase.—This phase of Duval fine sand occurs in but a few small areas, most of which are in the central part of the county. The soil occupies low ridges of the high undulating plain, and the slopes are gentle. Between the ridges some areas are flat and receive slight accumulations of washed-in soil material. In such locations, both surface soil and subsoil are less red than in the typical Duval soils.

The surface soil is reddish-gray or reddish-brown loamy fine sand about 10 inches thick, grading below into brown or reddish-brown fine sand, and this, at a depth ranging from 30 to 40 inches, into red fine sandy clay which, with increase in depth, is increasingly sandy and less red. At a depth of about 5 feet the subsoil is yellow fine sand or fine sandy loam, which, from 2 to 3 feet deeper, grades into gray fine sand or stratified packsand. No free carbonate of lime is present in any of the soil layers or in the substratum.

This soil differs from Duval fine sandy loam, shallow phase, in having a larger content of sandy material, a less red color, and in being in general more loose and permeable. It represents an advanced stage of soil development and has been leached of much of the soluble mineral constituents which sustain plant life. The natural vegetation comprises coarse grasses and herbaceous plants, together with a scattered growth of small shrubs such as mesquite and huisache trees. Where unprotected, the loose dry soil is blown and drifted in heavy winds, this tendency making crop production more uncertain than on the less sandy soils.

Owing to the gentle slopes and permeable character of the soil, a large proportion of the rain water is absorbed, and crops withstand long periods of dry weather, provided a good reserve of soil moisture has been stored prior to the growing season. All crops grown on Duval fine sandy loam will grow well on this soil, but yields are generally lower than on the fine sandy loam. The soil is better suited to vegetables, small fruits, and berries than to farm crops, and such crops as watermelons, peas, and sweetpotatoes do well. This soil is not very extensive, and little of the land is under cultivation.

Duval fine sand, depression phase.—The depression phase of Duval fine sand occurs in but a few small narrow areas occupying shallow valleys in the southeastern part of the county, largely in association with Duval fine sandy loam, deep phase. It occupies similar positions to Duval fine sandy loam, depression phase, and resembles and has the same general characteristics as that soil but differs from it in having a subsoil of fine sand instead of fine sandy clay.

Duval fine sand, depression phase, consists of a 16-inch layer of reddish-brown loamy fine sand underlain by brownish-red fine sand which changes to reddish-yellow fine sand below a depth ranging from 2 to 3 feet. The fine sand subsoil extends downward several feet, and no free calcium carbonate is in the surface soil or subsoil material.

Owing to its low position, this soil receives much of the rain water which runs off adjacent slopes, and its favorable character for storage of water enables crops to withstand seasonal dry periods much better than on more sloping soils. The general-farm crops are grown successfully, and yields are slightly lower than on the depression phase of Duval fine sandy loam. This soil is inextensive, and only a small part of the land is cultivated.

Webb fine sandy loam.—Large areas of Webb fine sandy loam occupy the smoother undulating areas in all parts of the county, except the southwestern quarter. Superficially, the soil resembles Duval fine sandy loam, but it differs from that soil essentially in having less red coloration and a more dense, heavy, and less pene-

trable clay subsoil. It is rather extensive, occupying 101.4 square miles, and a large acreage is in cultivation.

The 8- to 10-inch topsoil is brown or reddish-brown fine sandy loam or loamy fine sand. It rests on, or grades downward through, a thin transitional zone into dull-red heavy fairly tough clay which, at a depth of about 20 inches, grades into yellowish-red clay continuing downward to a depth ranging from 30 to 40 inches. The soil layers contain no free carbonate of lime to this depth, but below this is yellow calcareous clay containing limy concretions.

The surface relief is smoothly undulating, and most of the slopes are very gentle. Natural drainage is fairly rapid, and erosion of the unprotected surface soil is severe in some places. Owing to the dense clay subsoil, underdrainage is slow, and this less permeable material does not facilitate the absorption of water so well as does the more penetrable Duval fine sandy loam. Webb fine sandy loam is also less drought resistant than the Duval soil. A larger proportion of rain water is lost through run-off and, under irrigation, water is applied with more difficulty. The surface soil, although very friable under moist conditions, is said to crust slightly on drying after irrigation water has been applied.

The same crops are grown as on Duval fine sandy loam, but it is reported that yields are in general slightly lower. The Webb soil seems well suited to these crops, probably being somewhat better suited to certain field and truck crops than to fruits and berries.

Webb fine sandy loam, flat phase.—The flat phase of Webb fine sandy loam occurs in a number of areas in the eastern part of the county and includes a total area of 50.9 square miles. It occupies nearly flat areas and supports a rather thick growth of shrubs and grasses.

This soil differs from the typical soil in surface features and in a greater accentuation of the tendency of the topsoil to crust on drying, accompanied by physical characteristics of the subsoil which make it even less permeable than the corresponding layer of the typical soil.

The topsoil is brown or reddish-brown fine sandy loam or loamy fine sand about 10 inches thick. It rests on, or grades below through, a thin transitional zone into dull-red, reddish-brown, or brownish-red heavy and rather dense moderately tough clay. Below a depth ranging from about 18 to 24 inches, the clay subsoil is slightly yellow, becoming more yellow with increase in depth. Below a depth ranging from 24 to 30 inches, the material grades into yellow fairly friable clay which in places is calcareous. At a depth ranging from 3 to 4 feet the clay grades into yellow and gray fine sandy clay, the parent material, which, though not calcareous, in places contains some soft concretions of carbonate of lime. The topsoil is said to crust rather hard on drying after irrigation. This tendency is reported to have been greatly overcome in some places by the use of manure.

The soil is moderately extensive, but only a small acreage is cultivated. It is used mainly for the general-farm crops and seems better suited to these and to some truck crops than to many vegetables and fruits. Crop yields seem to be about the same as on the typical soil under similar moisture conditions, but probably the moisture conditions of the typical soil are slightly more favorable for crops in very dry seasons.

LIGHT-COLORED SOILS

The upland soils included within the light-colored group are not extensive, but they occupy small areas scattered over the undulating plain, mainly in the northern part of the county. Four soils are mapped, which are characterized by light-colored sandy topsoils low in organic matter, but they differ from one another considerably in the characteristics of their subsoils. They are Nueces fine sand, Brennan fine sandy loam, Miguel fine sandy loam, and Miguel fine sand, shallow phase. These soils and similar soils of light color occur in different parts of the Rio Grande plain, but in most sections they are comparatively inextensive and are in general less desirable for farm crops than the red sandy soils.

Nueces fine sand.—Nueces fine sand occurs in several small bodies in the northeastern part of the county. It is very different from the other soils of the county, owing to its very light texture and loose consistence to a depth of several feet. It is characterized by a natural growth of live oak and blackjack oak trees—a type of vegetative association not common in the Rio Grande plain.

The surface soil is loose gray fine sand ranging from 10 to 20 inches in thickness, the upper 1 or 2 inches being very slightly darkened by a small amount of vegetable matter. The gray fine sand grades below into pale-yellow fine sand which is very similar in texture and structure to the material above. This material continues to a depth of several feet with little change. Neither the surface soil nor the subsoil is calcareous, and examinations to a depth of 11 feet showed no carbonate of lime present.

The surface relief of Nueces fine sand is smooth, and the slopes are gentle, some areas being almost flat. The soil is so porous that it quickly absorbs practically all the rainfall and collects a supply of water which is, by reason of the coarse texture of the soil, readily given up to growing plants. The drought resistance of the soil is fairly good, as is evidenced by the good stand of coarse grasses and herbaceous plants occurring throughout the scattered tree growth during very dry seasons.

This soil is comparatively low in organic matter and in plant foods, and unless these are supplied crop yields are low. The soil drifts in heavy winds and injures young crops unless protection is provided. The very light soil is not well suited to farm crops but is suited to many vegetables, to vine crops, such as watermelons, and to peanuts, grapes, plums, and berries. Very little of the land is cultivated, but it is used for grazing. It is reported that in some other counties of the Rio Grande plain, this soil is successfully used in the production of watermelons, peanuts, grapes, plums, and various other crops.

Brennan fine sandy loam.—Brennan fine sandy loam is a light-colored soil of but slight extent in Frio County, but it occurs in good-sized areas in southern counties of the Rio Grande plain. It resembles Nueces fine sand in topsoil features but differs greatly from that soil in subsoil characteristics.

The 12- to 15-inch topsoil consists of grayish-brown loamy fine sand which is low in organic-matter content. When dry the immediate surface soil is very light colored. The subsoil is yellowish-brown or dull-yellow fine sandy clay or clay loam. At a depth ranging from 4 to 5 feet the clay is calcareous and contains much segregated soft carbonate of lime, though the topsoil and subsoil are noncalcareous.

The surface relief is smoothly undulating, and the soil absorbs a rather large proportion of the rain water. The topsoil packs rather hard in very dry seasons where not cultivated, and the subsoil dries to a hard compact mass but is moderately permeable.

Narrow strips of high flat land in some shallow valleys constitute small areas of this soil developed from ancient stream deposits resting on deeply buried beds of rounded gravel, although the typical soil of the highland plain has developed from older beds of sandy clay.

Brennan fine sandy loam is moderately productive and has about the same crop adaptations as Duval fine sandy loam. However, average yields are somewhat lower, and the drought resistance of this soil is perhaps not quite so good, except in particular locations. This soil is not cultivated largely and the chief crops grown are the general-farm crops, though the land is well suited to various vegetables, truck crops, small fruits, and berries.

Miguel fine sandy loam.—Miguel fine sandy loam is of slight extent. It is a light-colored soil of outstanding character and differs markedly from the other soils of this group. In surface features it is somewhat similar to Brennan fine sandy loam but differs from that soil in having a very dense clay subsoil.

The topsoil is brown or grayish-brown fine sandy loam about 10 inches thick, abruptly underlain by a very tough heavy clay subsoil which is brown or mottled brown, yellow, and gray. Below a depth ranging from 20 to 24 inches, the clay grades into yellow friable clay which is slightly calcareous and contains fine streaks and lumps of soft white carbonate of lime. At a depth of about 4 feet, this material grades into gray and yellow calcareous fine sandy clay containing some black concretions.

Miguel fine sandy loam occupies small flats and minor depressions near stream heads and is slowly drained by shallow gullies. Underdrainage is very slow, and in a region of greater rainfall this would cause very imperfect drainage. The impervious condition of the subsoil allows very slow accumulation of soil moisture, and, therefore, the soil, which is apparently of but moderate productiveness, would probably not acquire a good reserve of soil moisture very quickly. The natural cover over most of this land is a heavy growth of shrubs and small mesquite trees, with some grass. The land is used chiefly for livestock grazing.

Miguel fine sand, shallow phase.—The shallow phase of Miguel fine sand is of very slight extent. It occupies a few small areas in the central and northern parts of the county, the largest area occurring around Pearsall. This soil is very similar to Nueces fine sand in the surface and subsurface layers, but it differs materially from that soil in subsoil characteristics.

The topsoil is gray fine sand about 10 inches thick, grading into yellow fine sand which, at a depth ranging from 30 to 40 inches, rests on mottled yellow and brown tough sandy clay containing, in places, layers of ironstone crust. Neither surface soil nor subsoil is calcareous, and no carbonate of lime is present in the substratum, except in places where a thin layer containing limy concretions lies from 6 to 7 feet beneath the surface.

The surface relief is smooth, and the porous sandy layers absorb most of the rain water which is held beneath in the deep heavy clay. Therefore, the soil is fairly drought resistant.

This soil is best suited to melons, peanuts, other truck crops, small fruits, and berries. The land is not highly productive but will respond well to soil-improvement practices and fertilization under proper moisture conditions.

DARK-COLORED SOILS

The dark-colored upland soils occupy flat or smoothly undulating areas in different parts of the county but are more extensive in the northern part. These soils are not so extensively developed in Frio County as in some other counties of the Rio Grande plain. Six soil types and two phases are included in this group, and the textures are predominantly heavy. The dark-colored soils are Orelia clay loam, Orelia fine sandy loam, Victoria clay loam, with a light-colored phase, Victoria clay, Victoria fine sandy loam, light-colored phase, San Antonio clay loam, and San Antonio fine sandy loam.

The dark-colored soils are very productive, though they are not so drought resistant as the lighter-textured red soils. They are not suited to such a wide range of crops and are better adapted to the general-farm crops than to vegetables, most truck crops, and fruits.

The soils of the group are similar in color and in surface features, but they differ in characteristics on which are based series differences. The Victoria soils are calcareous and friable, the San Antonio soils are noncalcareous and of tight tough character when dry, and the Orelia soils are noncalcareous in the upper layers and are characterized by a rather dense but not excessively tight physical structure.

Where normally developed on smooth surfaces, the dark-colored soils are underlain by a definite layer of calcareous clay, in which is an accumulation of white chalky carbonate of lime.

Victoria clay loam.—Victoria clay loam is a dark-colored soil which, though occurring in a few moderate-sized areas in Frio County, is, with the Victoria clay, extensively developed in some other counties of the Rio Grande plain. Most of it is in the northern half of the county, the largest areas occurring northwest of Pearsall south of Frio River.

The surface soil is black or grayish-black calcareous heavy clay loam about 10 inches thick, grading through a transitional zone into very dark blackish-gray calcareous clay which, below a depth ranging from 18 to 24 inches, is light gray or yellow in color and contains lumps of soft white calcium carbonate. Below a depth ranging from 3 to 4 feet, this material grades into gray calcareous clay containing chalky material and some crystals of gypsum.

The topsoil of Victoria clay loam is granular and when cultivated under favorable moisture conditions works into a friable mass which is easily tilled throughout the growing season. The surface relief is very smooth, surface drainage is not rapid, and the heavy clay subsoil causes very slow underdrainage. Run-off of rain water is slow, and the heavy texture of both surface soil and subsoil causes slow absorption of water, and more rain is required to saturate the surface soil, subsoil, and substratum than is required for the more permeable sandy soils. This soil is somewhat less drought resistant than Duval fine sandy loam and similar soils, not only because of the less favorable physical structure but also because of the lower availability of soil moisture to plants in heavy soils. Crops withstand dry seasons very well on Victoria clay loam when the growing season begins

with a large supply of moisture stored in the surface soil and subsoil. The subsoil, though heavy, is by no means impervious, and it is sufficiently open to readily admit air, water, and plant roots.

The land is covered with a heavy growth of shrubs, small mesquite trees, and pricklypear. Buffalo and curly mesquite grasses, with some grama, abound in the less brushy areas.

Victoria clay loam is only moderately extensive, and only a small acreage is farmed. It is inherently very productive, and, when moisture conditions are favorable, high yields are obtained. The soil is well suited to cotton, corn, grain sorghums, sudan grass, broomcorn, and other crops of this character, and it is moderately well suited to some vegetables and truck crops. Farmers report yields of cotton ranging from one half to 1 bale and of corn from 30 to 60 bushels an acre. Some spinach, grown under irrigation, has yielded from 300 to 700 bushels, according to local truck growers, but it is stated that onions yield slightly less than on Duval fine sandy loam. Victoria clay loam is a valuable strong soil and, where good water can be obtained for irrigation, its use for crops should be consistently successful. At present most of the soil is used for cattle grazing, as the short grasses common to this soil are especially valuable and nutritious.

Victoria clay loam, light-colored phase.—Scattered throughout many parts of the county are some small and some fairly large areas of a light-colored phase of Victoria clay loam. This soil is similar to the typical soil in physical characteristics, in topographic features, and in character of vegetation, but it differs chiefly in the lighter color of the surface soil, probable higher content of calcium carbonate, and lower content of organic matter.

The 10-inch topsoil is calcareous brown clay loam, which on drying has a decidedly gray cast. The subsoil is lighter in color, having a yellow shade in places, and below a depth ranging from 16 to 20 inches it is friable calcareous yellow clay.

Soil of this phase has the same smooth surface relief and natural vegetal cover as the typical soil, and with adequate moisture it produces equally high yields of the various crops grown. It is moderately drought resistant, especially when a good store of moisture is in the subsoil and substratum at the beginning of the growing season. Some areas are farmed, and small irrigated fields are reported to produce excellent yields of spinach, onions, and corn. Irrigated truck farms on this soil in La Salle County are said to produce good yields of spinach, onions, cantaloups, and lettuce. The virgin soil is prized for grazing, on account of the natural growth of nutritious grasses.

Victoria clay.—Medium-sized areas of Victoria clay occur in the northwestern part of the county, south and northwest of Frio Town. This soil differs but little from Victoria clay loam in physical characteristics, moisture relationships, and agricultural adaptations. Its chief difference lies in the slightly darker, but materially heavier, topsoil which is heavy calcareous clay. On drying, the surface soil and subsoil shrink, and wide deep cracks form in the uncultivated soil. Minor surface inequalities, known as "hog wallows", characterize the surface of the virgin soil.

The surface soil is black calcareous clay about 12 inches thick, grading into dark-gray or nearly black calcareous clay. Surface drainage is slow, and the heavy clay subsoil is but slowly penetrated

by water. The soil is granular and works to a friable mass under proper moisture conditions. The drought resistance is moderately good, provided sufficient moisture has been collected in the surface soil and subsoil prior to the growing season.

Victoria clay is highly productive. It is better suited to cotton, corn, sorghums, and feed crops than to vegetables, other truck crops, and fruits, though some truck crops may be successfully grown. In some other counties of Texas, this soil is highly prized for cotton and other farm crops, but in Frio County all the soil is used for the ranch pasturage afforded by the valuable grasses, of which mesquite and buffalo grasses are the most abundant.

In places small rounded and subangular chert gravel are scattered over the surface, in some places being very abundant, but the gravel does not occur in the surface soil or subsoil. The largest area of this kind, shown on the map by gravel symbols, is in the extreme southeastern corner of the county.

Victoria fine sandy loam, light-colored phase.—The light-colored phase of Victoria fine sandy loam covers 10.1 square miles, most of which occurs in one area west of Schattel. A few small areas are southwest of Pearsall. This soil is similar in character to the light-colored phase of Victoria clay loam, except that the topsoil is fine sandy loam in texture. The surface relief is flat, and in places bordering stream bottoms some of the benches occupied by the soil resemble terraces of ancient alluvium, but soil characteristics are the same as of soils developed over marl on the upland plain.

This soil is fairly drought resistant, probably more so than the heavier soils of the dark-colored group, owing to the permeable topsoil which absorbs rain water more rapidly, less being lost by run-off than on Victoria clay loam. It is a highly productive soil suited to the general-farm crops and many of the truck crops grown in the county. It is reported that spinach, onions, cantaloups, lettuce, and many other truck crops are grown under irrigation on the same soil in La Salle County.

San Antonio clay loam.—San Antonio clay loam occurs in small bodies widely scattered throughout the county, principally the northern part, the larger areas occurring north and northwest of Pearsall. It is a dark-colored soil developed from calcareous parent materials and differs greatly in structure from Victoria clay loam.

The topsoil is a layer of brown clay loam about 8 inches thick, resting on a reddish-brown dense heavy clay subsoil which grades at a depth of about 20 inches into dull-yellow clay, slightly calcareous in the upper part and extending to a depth of several feet.

This soil occupies small flat depressed areas. It is not calcareous and is deficient in surface drainage and underdrainage. The very tough heavy clay subsoil allows very slow and imperfect penetration of air, water, and plant roots. The topsoil when very dry is tight and almost impervious.

This soil is probably much less productive than Victoria clay loam, owing largely to its unfavorable physical structure. It seems better suited to grain sorghums, sorgo, and other feed crops than to corn or truck crops. It is not cultivated in this county but is used mainly for the pasturage afforded by shrubs and grasses, some of which are valuable for browse and grazing.

San Antonio fine sandy loam.—San Antonio fine sandy loam is a soil of very small extent. It is similar to San Antonio clay, except that the topsoil is of fine sandy loam texture. The surface soil is very dark and sufficiently friable to allow easy cultivation, though it crusts on drying. This soil is moderately well suited to truck crops and to the general-farm crops but is used only for pasture. It is reported that San Antonio fine sandy loam is successfully used for the commercial production of strawberries in some sections of northern Atascosa County, where the land is irrigated. Some farmers believe that yields of the berries were increased by fertilizing with a 6:10:7 mixture, at a rate ranging from 200 to 300 pounds an acre.

Orelia clay loam.—Orelia clay loam closely resembles Victoria clay loam but differs from that soil in that it is noncalcareous, less granular, and less friable. However, its dense character is less pronounced than that of San Antonio clay loam. In physical character it seems to closely approach Wilson clay loam as developed in the humid region of Texas on the black-land prairies. Some areas occupy flat terraces in shallow valleys, and here the parent material seems to be largely of alluvial origin.

Orelia clay loam consists of a 10-inch layer of black clay loam underlain by black heavy clay which at a depth below 24 inches changes to brown calcareous clay. On drying, the surface soil becomes very hard and breaks to large clods which are broken down with difficulty.

The surface is flat, and drainage is slow. The heavy clay subsoil is penetrated slowly by water, air, and plant roots, though the material is by no means impervious, nor so dense as the subsoil of San Antonio clay loam.

Orelia clay loam is not very extensive, and little of the land is in cultivation. It is suited to the same crops as Victoria clay loam, but the less favorable structural characteristics give slightly lower drought resistance and, in general, it does not produce such large yields of most crops.

Orelia fine sandy loam.—Orelia fine sandy loam occurs in a few widely scattered small areas. It differs from Orelia clay loam chiefly in the lighter texture of the surface soil which is fine sandy loam about 10 inches thick. Like Orelia clay loam, the surface soil and upper part of the subsoil are noncalcareous, but the deeper clay contains a fair quantity of calcium carbonate.

Only a few small areas of this soil are cultivated, and, when moisture conditions are favorable, good yields are obtained. The land has about the same crop adaptations and productiveness as the light-colored phase of Victoria fine sandy loam.

ALLUVIAL SOILS

The alluvial soils of Frio County are potentially the most highly productive soils of this section of Texas. They occur in continuous strips in the first bottoms of the rivers and larger creeks, which flow through or originate within the county. The larger streams are Frio and Leona Rivers and Hondo, San Miguel, Elm, Seco, Todas Santos, and Black Creeks.

Most areas of the alluvial soils are nearly flat, and drainage is slow. Occasional overflows cover the surface with water for short periods, but they are so infrequent that they do not constitute a serious hin-

drance to cultivation. In a region of such light rainfall, slow drainage is a feature which is in general not unfavorable, as the surface soils and subsoils, even those of heavy texture, are sufficiently permeable to allow water to gradually pass downward. The flat surface is here a decided advantage in the collection of rain water which can be held in reserve in the deep soils for use by growing plants.

In most places the alluvial soils are covered by a rather thick growth of trees, largely of humid-region types, consisting of live oak, elm, hackberry, ash, pecan, and other trees of similar character, but in many places, mainly in areas of the heavier soils away from the stream banks, mesquite trees are abundant. Short grasses grow luxuriantly in the more open places.

The alluvial soils comprise water-deposited sediments made up of soil materials washed from the surface of upland soils within the county or from soils lying within the drainage area of streams which originate some distance outside. These soils differ from the upland soils in that the topsoils and subsoils are not sharply differentiated; in that the topsoils and subsoils are deeper and generally contain a larger proportion of organic matter and available plant foods; and in that the heavy-textured soils are more permeable and have, in general, a greater degree of drought resistance. Under similar climatic conditions the alluvial soils produce higher yields than upland soils of corresponding texture.

The alluvial soils are included in the Frio, Leona, and Blanco series. These soils, though very similar in character, differ chiefly in color and in organic-matter content, both of which are largely influenced by the character of the parent materials and the manner of deposition.

The alluvial soils are highly productive and are suited to all the crops commonly grown, their adaptability to the different crops being governed largely by textural differences and moisture relationships. Very small acreages of the alluvial soils are in cultivation, owing perhaps to the greater cost of clearing the land, and in part to other economic reasons which at present favor the development of the more accessible areas of easily cultivated uplands.

These soils are especially suited to corn, alfalfa, cotton, feed crops, and certain truck crops. Where underdrainage is especially favorable, by reason of the presence of beds of gravel or sand lying a few feet beneath the surface, the native pecan grows luxuriantly and indicates a preference which can well act as a guide for the selection of soils for the extension of pecan growing. The soils are for the most part highly calcareous, friable, of granular structure, and have a physical character that favors a rapid growth of plants.

Frio silty clay.—Frio silty clay consists of dark-gray silty clay which grades, at a depth of about 8 inches, into slightly lighter colored silty clay several feet thick. The flat surface lies from 10 to 15 feet above stream level, and both surface drainage and subdrainage are slow. Though of heavy texture, the soil is readily worked into a friable mass under proper moisture conditions. It is a highly productive soil, especially suited to corn and alfalfa, and many other crops do well. Pecan trees, where surface drainage and underdrainage are good, make a splendid growth, but low flat areas, where underdrainage is slow, are much less suited to this tree.

Frio fine sandy loam.—Frio fine sandy loam is brownish-gray calcareous fine sandy loam to a depth of about 10 inches. It grades into a thick layer of gray, brown, or yellowish-brown fine sandy clay. This soil occurs in narrow strips along small streams and in places along the banks of the larger streams. The land lies slightly higher than the adjacent alluvial soils, and surface drainage and underdrainage are comparatively free. The soil is friable and can be worked under a wider range of moisture content than the heavier soils. It is suited to all the farm crops of the county, though it is better suited to some truck crops than are the heavier soils. Potentially it is of somewhat lower yielding capacity for farm crops than the heavier alluvial soils, but because of its favorable location and ease of cultivation, the average yields under present conditions would probably not differ greatly. On the calcareous typical soil, pecan trees make a splendid growth.

On some very narrow areas along small streams originating in noncalcareous soil areas within the county, this soil is noncalcareous, and, owing to imperfect underdrainage, the subsoil is of mottled colors.

Leona clay.—Leona clay differs little from Frio silty clay, except in color. The Leona soil consists of black calcareous clay grading, at a depth of about 20 inches, into brown calcareous clay which, below a depth ranging from 2 to 3 feet, becomes grayish brown. This soil is of very small extent. It contains a larger amount of organic matter than the Frio soils, and it seems probable that under cultivation crop yields should be as high, or perhaps higher, than on Frio silty clay. It is suited to about the same crops.

Blanco silty clay loam.—Blanco silty clay loam is light-gray calcareous silty clay loam which grades, at a depth ranging from 10 to 15 inches, into yellowish-gray silty clay or silty clay loam many feet thick. In places interbedded layers of sandy material occur throughout the subsoil. Many fragments of snail shells occur over the surface and throughout the soil mass.

Blanco silty clay loam differs from the Frio soils chiefly in the much lighter color which in places is nearly white on the immediate surface of the thoroughly air-dry material. In other physical characteristics it is much like Frio silty clay, though it is reported that in places the moisture-holding capacity of Blanco silty clay loam is not high, owing, perhaps, to underlying sandy strata which cause excessive underdrainage. This feature is probably not present in most areas. The land seems to be highly productive, though only a very small proportion is cultivated. It seems well suited to corn, Sudan grass, and other farm crops and probably would produce good yields of many of the truck crops.

SOILS OF LOW AGRICULTURAL VALUE

This group includes soils which, under natural conditions, are not well suited to the production of cultivated crops. These soils are divided into two subgroups. The first subgroup includes soils which, though sufficiently smooth to allow ready cultivation, are so thin and droughty that yields under dry-farming practices would be generally unprofitable or, even if it were possible to irrigate the land, seem too unproductive to repay efforts and cost of improvement to the point of even moderate crop yields. These soils, Webb clay loam, Randall

clay, and Maverick fine sandy loam, are not extensive but occupy a number of areas in the southeastern, southwestern, and northwestern parts of the county, respectively. The second subgroup, in addition to thin soils of low productiveness, is made up in large part of gravelly or stony material which renders cultivation impossible in most places. Webb stony fine sandy loam, Webb gravelly fine sandy loam, and Maverick gravelly fine sandy loam comprise this subgroup.

THIN DROUGHTY SOILS

Webb clay loam.—Webb clay loam occurs in a few bodies in southeastern Frio County, its total area being 9.6 square miles. It belongs to the red-soil group, so far as soil character is concerned, but owing to its low value for crops under natural conditions in this county, it is placed in another group. The surface soil is a thin layer of reddish-brown clay, clay loam, or fine sandy loam ranging from 1 to 6 inches in thickness. This material grades into reddish-brown rather tough clay which, below a depth ranging from 12 to 18 inches, is reddish yellow. At a depth ranging from 18 to 24 inches, this material, in turn, grades into yellow calcareous clay and this, at a depth of approximately 2½ feet, into mottled gray, brown, and yellow clay. In places thin sandstone strata lie from 2 to 4 feet beneath the surface. In places the soil seems to be simply fine sandy loam, from which most of the topsoil has been removed by erosion. The soil occupies undulating or moderately sloping positions and is subject to severe erosion. It is covered more or less thickly with clumps of thorny shrubs and a small amount of grass.

The soil seems to be of droughty character and probably is of low productiveness generally, though some of the very smooth areas may be well suited to the general-farm crops and would probably produce fair yields when moisture conditions are especially favorable.

In order to be improved and built up to a better state of productiveness, the soil should have organic matter supplied and be protected from erosion. It is used chiefly for livestock grazing, as grama and other short grasses grow fairly abundantly on the deeper, less sloping areas.

Randall clay.—Randall clay occurs as small depressed areas, mostly lake beds, which in rainy seasons are covered with water. The soil is very dark gray or black very dense heavy clay which contains thin streaks of rust brown and yellow. This soil is several feet deep, and below a depth ranging from 3 to 4 feet the color is bluish gray. The surface soil and subsoil are exceedingly tight and tough, and there is practically no underdrainage. Many of the widely scattered areas are circular in shape and range from 10 to 40 acres in extent. When thoroughly dry, wide cracks form on the surface and extend downward to a considerable depth. Much surface water flows into the depressions occupied by this soil, and, as there is no surface drainage or underdrainage, water stands until removed by evaporation.

The characteristic vegetation is a shrub known as "retama," and very little grass or other plants grow on this soil.

Owing to the absence of drainage and the extremely intractable character of this soil, it is not suited to growing crops and is not farmed.

Maverick fine sandy loam.—Maverick fine sandy loam occurs in a number of areas widely scattered throughout the central and northwestern parts of the county. It includes a total area of 50 square

miles. The surface soil consists of grayish-brown fine sandy loam or loamy fine sand, about 8 inches thick, which dries out on the surface to a light-gray color. The subsoil, to a depth ranging from 24 to 30 inches, is brownish-gray or yellowish-gray calcareous fine sandy loam or fine sandy clay loam, resting on a bed of almost pure carbonate of lime (caliche) which in places is several feet thick. In many places the caliche, more or less hardened by drying, lies at a depth ranging from only 15 to 30 inches beneath the surface.

The surface relief is smoothly undulating, though some slopes are fairly steep. Underdrainage, as well as surface drainage, is rapid, and, as rain water does not become abundantly stored in the surface soil and subsoil layers, the soil is droughty.

Most crops of the region will grow well on this soil when moisture is abundant, though yields in general are not high, as the soil is not highly productive. Very little of the land is cultivated, though some areas have been irrigated and crops have been successfully produced where a large supply of water is available.

The soil is used chiefly for grazing livestock, as the moderately heavy cover of vegetation, consisting largely of short grasses, constitutes valuable range forage. Many kinds of shrubs grow in thickly dotted clumps, and some of these afford excellent browse for cattle and goats.

GRAVELLY AND STONY SOILS

Maverick gravelly fine sandy loam.—Maverick gravelly fine sandy loam, occupying areas locally known as "blackbrush and huajillo hills", is much like Maverick fine sandy loam, except that it is much shallower and contains a rather large quantity of gravelly material. It occurs in a number of large and small bodies in the northern part of the county and covers a total area of 61.1 square miles. This soil consists of a few inches of gray fine sandy loam resting on caliche beds several feet thick, the upper part of which is hard. A large proportion of the soil mass consists of hard caliche fragments, and in places it contains some rounded chert gravel. The surface relief is smoothly undulating.

This soil is too thin for use for farm crops and is all included in pastures of large ranches. Many kinds of shrubs, chiefly black chaparral, huajillo, pricklypear, and cenizo, grow thickly, and many of them are highly valued as browse for goats. Grass makes a thin growth and affords only a scant pasturage for cattle.

Webb gravelly fine sandy loam.—The surface soil of Webb gravelly fine sandy loam, is brownish-red fine sandy loam, ranging from 4 to 8 inches in thickness, which contains a large quantity of small rounded chert gravel. The subsoil consists very largely of a bed of rounded gravel, together with some brownish-red clay which comprises the small content of fine earth. At a depth ranging from 2 to 4 feet, the subsoil rests on hard white caliche, in many places containing a large quantity of gravel. The caliche bed ranges from a few inches to 3 feet in thickness and rests on layers or beds of hard packsand or soft limestone. This soil occupies smooth broad ridges and gently rolling highlands.

Owing to the thin surface soil and large content of gravel, this soil is not suitable for cultivated crops. It supports a rather heavy growth of shrubs, chief of which are blackbrush, huajillo, catclaw,

and pricklypear, and an occasional mesquite. The land is used as pasture for livestock and is especially valued for the abundant browse furnished goats by several of the shrubs, chiefly huajillo.

Webb stony fine sandy loam.—Webb stony fine sandy loam occupies some small areas of hilly or rolling land in the southern and southeastern parts of the county. It has a total area of 16.7 square miles. This soil consists of a 4- to 8-inch layer of red or reddish-brown fine sandy loam, in most places resting on a deep bed of broken sandstone fragments underlain by soft sandstone strata. The soil contains a large quantity of small ironstone and ferruginous sandstone fragments, many of the larger fragments being of concretionary form. In most places there is no caliche beneath this soil, but, in places, seams between rocks are thinly coated with calcium carbonate. About the same character of natural vegetation grows as on the other gravelly soils, and the land is used for pasture, being more especially suited for goats, on account of the valuable shrub browse.

The shrubs on this soil and on many other soils provide a valuable source of honey-making material, and in some sections many hives of bees are kept and honey of excellent quality is produced commercially.

IRRIGATION

Irrigation in Frio County dates back to 1905, when an artesian well was brought in on the Schreiner & Halff farm 4 miles southwest of Pearsall. This well flowed about 500 gallons a minute. The water was used for irrigating 30 acres of onions, and the results obtained proved very successful. In 1908, the second artesian well was brought in about 5 miles southwest of Pearsall. Since this date, nine artesian wells have been brought in in Frio and Leona Valleys. As wells were brought in below the original well, the upper wells ceased flowing, but on the pump they were capable of producing 800 gallons a minute. The Bennett well at Derby was drilled in 1917 and produced 1,000 gallons a minute natural flow and 2,000 gallons a minute on the pump. These artesian wells range from 1,400 to 1,700 feet in depth. The first shallow wells used for irrigation were put in north of Pearsall in 1914. Others are in the vicinities of Pearsall and Dilley. The wells in the Pearsall territory are from 90 to 125 feet deep, and those around Dilley are from 300 to 450 feet deep. The Pearsall wells pump an estimated flow of 90 to 100 gallons of water a minute and the Dilley wells from 150 to 250 gallons a minute.

Farms irrigated from artesian wells range in size from 25 to 150 acres, and those irrigated from shallow wells, from 5 to 25 acres. Most of the farmers have concrete storage reservoirs and thereby increase the acreage that can be irrigated.

The principal crops irrigated are onions and spinach, with small acreages of cauliflower, citrus fruits, beets, carrots, and cabbage. All these crops do well under irrigation.

According to the 1930 census, about 1,100 acres are under irrigation in the county, and from all information obtainable this acreage can be greatly and safely increased.

The water is of good quality for irrigation. Chemical analyses of the water in many of the wells shows no evidence of sufficient injurious salts to be harmful to plants. Table 4 gives the results of chemical analyses of the water from a number of wells.

TABLE 4.—*Chemical analyses of water from wells in Frio County, Tex.*[1]

Location	Depth	Parts per million of—								Remarks
		Carbonate of lime	Sulphate of lime	Calcium chloride	Carbonate of magnesia	Sulphate of magnesia	Chloride of magnesia	Sulphate of soda	Chloride of soda	
	Ft.									
Joe Loxton farm, 14 miles west of Pearsall.	500	95	7	----	----	119	----	112	422	
Cy. Park farm, 22 miles southwest of Pearsall.	300	70	250	----	----	194	----	66	266	
E. W. Stanford farm, 4 miles west of Dilley.	250	23	447	----	----	447	----	721	1,353	
Buck Powers farm, 7 miles northwest of Dilley.	200	25	49	----	----	74	7	----	54	
R. B. Kothman farm, well no. 3, 5½ miles west of Hindes.	165	70	753	----	----	751	----	371	908	Water within 65 feet of surface. 160 feet of casing.
Harry Bennett farm, well no. 2, ½ mile southwest of Dorley Grocery Co.	450	78	1,159	257	----	----	342	----	1,079	Used for livestock only. Shows white incrustation on irrigation.
E. W. Shaw farm, 1 mile north of Pearsall.	90	63	400	164	----	----	116	----	348	Irrigation and household use. No casing. 40 feet to river.
W. R. Hindes farm	90	57	----	----	35	----	----	893	1,007	White incrustation on soil. Killing effect on plants.
Mason Maney farm, ½ mile north of Pearsall	90	41	311	166	----	----	120	----	523	No casing. Used for irrigation.
McKinley farm, 4 miles southwest of Melon.	180	68	313	----	----	247	----	50	1,577	Used for livestock and garden.
Southwest of Pearsall	50	43	180	53	----	----	97	----	348	Domestic use and flowers.
Eldridge farm, 10 miles west of Poteet.	640	25	49	50	----	----	28	----	21	Deep flowing well cased 500 feet. Irrigation and household use.
Joe Marion farm, 8 miles southwest of Hindes.	186	58	726	----	----	641	----	408	635	140 feet of casing. White incrustation on soil. Leaves brown sediment in teakettle.
Harry Bennett farm, well no. 1, ½ mile southwest of Derby Grocery Co.	285	48	90	----	----	98	----	634	764	Irrigation and domestic use.
R. B Kothman farm, well no. 2, 5 miles west of Hindes.	125	40	398	----	----	301	----	139	1,031	120 feet of casing. Water within 40 feet of surface. Cannot be pumped dry with engine. Used for irrigation and livestock.
J. L. Hammett farm, ½ mile west of Pearsall.	40	105	214	----	----	277	----	686	254	Dug well. Domestic use and orchard irrigation.
Clyde McKinley home at Melon.	190	63	362	----	----	289	----	272	858	Domestic use and irrigation.
R. L. Brown home, 1 mile north of Pearsall.	72	68	156	152	----	----	61	----	149	12 feet to river. Domestic use and irrigation.

[1] Analyses by G. S. Fraps, State chemist.

NOTE.—Chemically, water from many of these wells is good for irrigation and domestic use. In a few, the salt content is sufficiently high to require special care in use for irrigation, in order to prevent salt accumulation in the soil.

The land seems well suited to irrigation, as most of the soils are naturally well drained and there is little danger of "subbing." Several field tests were made on different soils with a Wheatstone bridge, and the soils were found to be practically free of injurious quantities of soluble salts. There is a possibility, however, if irrigation is practiced extensively, that on the low-lying imperfectly drained soils injurious quantities of salts may accumulate.

SOILS AND THEIR INTERPRETATION

The general characteristics of the soils express the effect of soil development in a warm, dry, subhumid climate and under a cover of mixed grass and brush. The minor soil characteristics, on which

are based the differentiation of the soil units, or as they are called, soil types, as shown on the soil map, express the effect of local influences, such as surface relief, drainage, erosion, differences of vegetation, and differences in geological formations. Briefly, it may be explained, the soil characteristics are the results of change in chemical composition and physical properties of geological materials into definite natural bodies (soils) whose characteristics are entirely different from those of the formations themselves. These changes are induced by moisture conditions, air, and temperature, through leaching, oxidation, aeration, the accumulation of organic matter, and the shifting of materials from one position to another, all of which have been brought about by the forces existing in the climate and in the organic life of the area, mainly vegetation.

Frio County lies in the subhumid part of southern Texas on the Rio Grande plain—a smooth, brushy grassland of great extent. The soils are of pedocalic character, having been developed under a grass cover in a comparatively warm climate with moderate rainfall and high evaporation, where the normal soils, regardless of the character of the parent materials, are characterized by an accumulation of calcium carbonate in some horizon of the soil profile. The soils have been developed from unconsolidated parent materials, one division of which is mainly a calcareous clay and another comprises noncalcareous sandy beds, all of these representing formations which in the humid region give soils of entirely different general characteristics.

The soils of the county fall into four groups, each based on certain major soil characteristics. These are (1) dark-colored soils, (2) red soils, (3) light-colored soils, and (4) alluvial soils.

The dark-colored soils have developed from calcareous clays which constitute some important formations extending across the State from the black-land prairies of the eastern or humid region. These soils are mostly of heavy texture and have developed on very smooth nearly flat surfaces under a short-grass cover, although a fairly heavy growth of small brushy trees and shrubs occurs in many places. These soils do not occupy such extensive areas here as in some other parts of the Rio Grande plain. They have here been included in the Victoria, Orelia, San Antonio, and Maverick series.

The red soils have developed from noncalcareous beds of sandy materials, mostly unconsolidated but in places containing thin strata of sandstone. Most of these soils are of sandy texture and occupy large areas throughout the Rio Grande plain. The parent materials represent formations on which have developed large areas of timbered sandy soils in that part of the humid region known as the "east Texas timber country." These soils have developed on smoothly undulating or gently rolling surfaces beneath a cover of coarse bunch grasses associated with a scattered growth of small trees and shrubs. The soils of this group have been correlated in the Duval and Webb series.

The light-colored soils are not of great extent, but they comprise important bodies of land in certain parts of the Rio Grande plain. These soils, also, have been developed from unconsolidated beds of sandy materials from formations which give rise to light-colored pedalfers in the east Texas timber country. Most of the soils of this group have developed beneath a coarse bunch-grass cover. They have been correlated in the Nueces, Miguel, and Brennan series.

Most of the alluvial soils are deep, calcareous, and friable, and they consist of soil materials, washed largely from the soils and calcareous formations of the Edwards Plateau. These materials have no well-developed characteristics, as they are subjected to occasional change by added sedimentation of soil materials during periodic overflows. They are of the Frio, Blanco, and Leona series.

The soils have developed under a rainfall which averages but little more than 20 inches annually. The amount of rain that falls in a year is very variable, having been as low as 6 inches in 1 year and as high as 39 inches during another. However, the rainfall has provided sufficient water to leach the upper soil layers of much of the calcium carbonate, leaving it concentrated in a layer lying from 2 to 4 feet beneath the surface of the more maturely developed soils.

The normal regional soil profile is as follows:

1. A noncalcareous surface layer, lighter in texture than the layers beneath.
2. A developed heavier layer, in which there has been a concentration of clay and a removal of calcium carbonate.
3. A heavy layer which is more friable and somewhat lighter in texture than the layer above and which contains a large amount of calcium carbonate.
4. The parent material which contains less calcium carbonate than the horizon above.

The red soils and the light-colored soils, developed largely from highly siliceous materials, occur on smooth surface relief, though they are sufficiently sloping in places to allow some erosion. Owing to the permeability of these soils, the downward movement of soil water has caused leaching and eluviation to occur at a comparatively rapid rate, with the result that loose friable highly siliceous sandy topsoils prevail, overlying subsoils which, as a rule, contain more clay and silt than the layers above. The natural vegetal cover, consisting chiefly of a rather thin growth of coarse bunch grasses, does not supply a large amount of organic matter, as the loose topsoils allow rapid oxidation of vegetable matter. Removal of calcium carbonate from the upper soil layers has been complete, because of the free movement of water through the sandy layers, and beneath most of the soils of normal development the zone of accumulation is definite, though in the extremely loose sandy soils the entire profile shows little evidence of lime.

Duval fine sandy loam is representative of the red soils group. The solum consists of three major horizons, each of which has subhorizons, in which are minor differences in characteristics. A gradual change occurs between the horizons, and none is separated by sharp distinctive division lines. The soil profile shows the following layers:

1. Loose friable red or brownish-red noncalareous loamy fine sand or fine sandy loam, from 10 to 15 inches thick. This horizon consists of two subhorizons—(*a*) about 3 inches of brownish-red surface soil containing a slight amount of organic matter and (*b*), from 3 to 15 inches, red material containing very little or no organic matter. This material grades through a thick transitional zone into the second horizon.
2. Friable very permeable noncalcareous red sandy clay from 2 to 3 feet thick, which on drying breaks to large irregular hard clods with no lines of natural cleavage. The material is not very sticky when wet. This horizon is subdivided into two subhorizons—(*a*), in which the upper 12 or 18 inches is of deep-red color and grades through a very thick transitional zone into the lower part, and (*b*), yellowish-red material, the yellow color increasing very gradually with increase in depth. The upper subhorizon contains a larger proportion of clay than does the lower. This material grades through a thin transitional zone into horizon 3.

3. The horizon of calcium-carbonate accumulation. This is a layer of yellow or reddish-yellow calcareous fine sandy loam or fine sandy clay containing lumps, concretions, and thin layers of soft calcium carbonate. In places the upper part of the layer, which is 2 feet or more thick, consists almost entirely of calcium carbonate. This material hardens as it becomes air-dry and is locally known as "caliche." The fine earth of this layer is friable and crumbly and readily permeable. The material is underlain by a thin transitional layer.
4. The parent material which consists of noncalcareous sandy clay.

The Webb soils of the red group are somewhat similar in color to the Duval soils, but differ from those soils in the different horizons, especially horizon 2, as the material is harder and tough when dry, is less permeable, and is penetrated more slowly by water and plant roots. The surface soil and subsoil layers contain more clay than the corresponding layers of the Duval soils, and the parent material of the Webb soils is a fairly dense noncalcareous sandy clay of mixed yellow and gray colors. The Webb soils are somewhat less red than the Duval.

Webb fine sandy loam is the principal soil type of the Webb series. It differs from Duval fine sandy loam in that the soil material contains more clay and on drying is more compact and less permeable, especially in horizon 2. The layers grade to one another through thinner transitional layers and therefore are more sharply differentiated.

Horizon 2 is dull-red or brownish-red fairly tough clay (yellowish red in the lower part) which on drying becomes very hard and cracks to small very hard angular clods. The clods are less red on the outside than on the inside. The layer of lime accumulation is from 1 to 3 feet thick and, as a rule, contains less limy material than the corresponding horizon of Duval fine sandy loam.

The light-colored soils have the same general horizonal development as the red soils. They contain, however, a very large proportion of gray or brownish-gray fine sand. Owing to the coarse-grass vegetation and an open structure favoring rapid oxidation, the amount of organic matter present is small.

Brennan fine sandy loam has a light-gray surface horizon, but horizon 2 is yellow sandy clay. In horizonal arrangement the soil profile is much like Duval fine sandy loam, but the color of the soil material in each layer differs, and the material of horizon 2 becomes much more compact when dry, although it is very permeable. The soil has developed under a coarse bunch-grass vegetation providing little organic matter. The parent material is sandy clay similar to that giving rise to the Duval soils, but, as a rule, the Brennan soil has developed on flat areas where drainage is less free than in the Duval soils.

Miguel fine sandy loam differs from the other light-colored soils in the presence of a heavy tough clay or claypan lying immediately beneath the grayish-brown surface soil. This clay, on drying, cracks to blocky clods which are slick and darker on the outside than within. The Miguel soil has developed in small areas of low flats and depressions.

The light-colored soils, though of small extent, represent a wide range in textural and structural character, the Nueces soil of loose deep sand constituting an excessively leached soil, and the Miguel soils being dense and almost impervious.

The dark-colored soils have developed from calcareous clays. They are chiefly of heavy texture, the clay loams predominating. These soils, although heavy and containing much clay material, are permeable, and they allow moderately free underdrainage in proportion to the character of developed physical structure. They have developed under a short-grass cover consisting chiefly of buffalo and curly mesquite grasses which have supplied the soils with sufficient organic matter to give them a dark color.

These soils have been developed on nearly flat surfaces and therefore have more or less well developed characteristics. Owing to the heavy texture of the layers and slow downward movement of water, the calcium carbonate is less thoroughly leached from the soil layers than in the more permeable soils of the red and the light-colored groups. As compared to the more siliceous soils of both the red and the light-colored groups the horizons of the normal soil profile contain a larger amount of clay, are darker, and contain a larger amount of calcium carbonate and other constituents in the form required for plant growth. The various horizons have fewer distinctive differences than occur in the horizons of the soils of the other groups and for the most part grade into one another through very thick transitional zones.

The Orelia soils are the most advanced in stage of development of the dark-colored soils, and they are less friable than the other members of the group. The profile of Orelia clay loam consists of the following layers:

1. 0 to 10 inches, black clay loam which does not effervesce with hydrochloric acid. When dry the material is dark ash gray and is very hard and massive. It breaks with considerable force into large hard irregular clods. This layer grades through a thin transitional zone into the second layer.
2. Black heavy noncalcareous clay which when dry breaks naturally into small cubical smooth-surfaced clods and at a depth of about 2 feet grades into the third layer.
3. Yellow or brown calcareous clay containing soft calcium-carbonate concretions. This is the layer of carbonate accumulation and ranges from 2 to 3 feet in thickness. In places small particles of gypsum are present.

This material grades below into parent material consisting of yellow and gray slightly calcareous clay which also contains some particles of gypsum.

This soil has developed on very flat surface relief, beneath a short-grass vegetation. In physical character the upper two horizons are much like the Wilson soils of the humid region.

The Victoria soils, which are comparatively young in stage of development, are calcareous in all horizons, the material is friable, and even in the heaviest layers it breaks down naturally to small sharp grains. The horizon of lime accumulation is not distinctly developed, in sharp contrast to the horizon above, but consists of very light gray or yellow calcareous clay containing lumps and concretions of calcium carbonate. In physical characteristics these soils correspond in the upper horizons to the Houston soils of the humid region of Texas. The surface is smooth but as a rule is less flat than that of the Orelia soils, and perhaps for that reason the Victoria soils have been leached less thoroughly.

Table 5 shows the pH values of several soils mapped in the county. These values were determined by the electrometric method in the laboratory of the Bureau of Chemistry and Soils, United States Department of Agriculture.

TABLE 5.—*pH determinations of samples of several soils in Frio County, Tex.*

Soil type and sample no.	Depth	pH	Soil type and sample no.	Depth	pH
Duval fine sandy loam:	*Inches*		Orelia clay loam:	*Inches*	
447830	0- 4	7.70	447855	0- 4	8.60
447831	4-10	6.50	447856	4-15	8.93
447832	10-38	6.82	447857	15-30	8.05
447833	38-60	8.25	447858	30-48	7.92
447834	60-72	8.39	Victoria clay loam:		
Webb fine sandy loam:			447859	0-10	8.03
447846	0- 3	6.32	447860	15-28	8.30
447847	3-10	6.14	447361	28-48	8.98
448748	10-22	7.55			
448749	22-40	8.45			
447850	40-60	8.50			

The San Antonio soils represent an advanced stage of development. The soil material is less dark and less friable, and horizon 2 is very tight and dense when thoroughly dry. The material cracks naturally to small blocky clods. These soils have developed under a mixed growth of short and small bunch grasses on very flat or slightly depressed areas.

The Maverick soils comprise shallow eroded layers of dark-colored soils overlying caliche and are simply badly eroded spots of some of the deep normal dark-colored soils. These soils are less dark than the other dark-colored soils, owing to their low content of organic matter from the very thin grass cover they support.

The alluvial soils of the county consist of soil materials washed mainly from calcareous soils and formations. Most of them are deep, calcareous, friable, and well supplied with finely divided organic matter. The Frio soils are brown or grayish brown, the Blanco soils are gray or light gray, and the Leona soils are nearly black. These soils have no characteristic profile developments, though in places where gravel beds facilitate underdrainage the oxidation of the soil material is more advanced, as indicated by the developed yellow color of the subsoil.

Table 6 gives the results of mechanical analyses of samples of four representative soils.

TABLE 6.—*Mechanical analyses of samples of four representative soils in Frio County, Tex.*

Soil type and sample no.	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
Duval fine sandy loam:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
447830	0- 4	0.0	0.1	0.3	39.0	45.6	6.4	8.4
447831	4-10	.0	.1	.3	32.7	48.4	6.7	11.8
447832	10-38	.2	.1	.3	34.2	39.9	6.5	18.8
447833	38-60	.3	.1	.2	31.2	42.2	7.0	18.9
447834	60-72	.7	.5	.5	22.8	37.5	12.4	25.5
Webb fine sandy loam:								
447846	0- 3	.0	.3	.9	21.3	56.9	9.8	10.7
447847	3-10	.1	.3	.7	15.1	61.8	9.8	12.0
442848	10-22	.2	.3	.7	19.4	43.0	8.0	28.4
447849	22-40	.5	.2	.3	15.5	52.4	8.6	22.6
447850	40-60	.1	.2	1.0	26.3	49.5	5.4	17.6
Orelia clay loam:								
447855	0- 4	.5	.3	1.5	9.5	14.8	29.3	44.1
447856	4-15	.2	.3	1.4	9.6	12.6	29.4	46.4
447857	15-30	.5	.4	1.3	7.9	11.6	31.1	47.2
447858	30-48	.3	.4	.4	2.3	6.6	40.2	49.9
Victoria clay loam:								
447859	0-10	.3	.6	2.2	17.4	35.6	19.6	24.2
447860	15-28	.2	.6	2.1	15.5	30.8	19.8	31.1
447861	28-48	.6	.4	1.2	8.6	20.2	29.1	39.8

SUMMARY

Frio County is in the southwestern part of Texas. Pearsall, the county seat, is about 50 miles southwest of San Antonio. The county comprises an area of 1,124 square miles, or 719,360 acres.

Physiographically, the county is a plain dissected by comparatively narrow and shallow stream channels. Many flat areas and well-defined gravelly and stony ridges occur throughout the county.

The population of the county is 9,411, 73.1 percent of which is classed as rural. A large proportion of the inhabitants are Mexicans. Pearsall, the county seat and largest town, has a population of 2,536.

Railroad facilities seem to be sufficient at the present time. The San Antonio-Laredo paved highway (United States Highway 81) passes through the central part of the county. The other roads are fairly well maintained.

The climate is very mild, with rather long hot summers which are modified by a good Gulf breeze. The winters are short and very mild. The average annual rainfall is 20.52 inches, and the distribution is normally more abundant throughout the growing season.

The greater part of the county is suited to agriculture. Cotton and corn are grown on the largest acreages. Spinach, onions, beans, tomatoes, and cauliflower are the principal crops grown under irrigation. Only about 15 percent of the land of the county is devoted to crop production, the remainder being used for grazing cattle, goats, and sheep.

Twenty-one soil types and 9 phases of types representing 13 soil series are mapped. The soils range in texture from fine sand to clay, the fine sandy loam texture predominating.

Most of the soils are productive when soil moisture is sufficient. Irrigation has proved successful with a large variety of crops.

Frio County includes large tracts of good land that are agriculturally undeveloped. Successful crop production can be assured by increased irrigation. The most promising development of agriculture seems to be in the irrigation of truck crops and possibly of citrus and other fruits. With increased settlement and the exploration of the possibilities and extent of underground water supplies, crop production may be extended to cover such soils as can be economically utilized.

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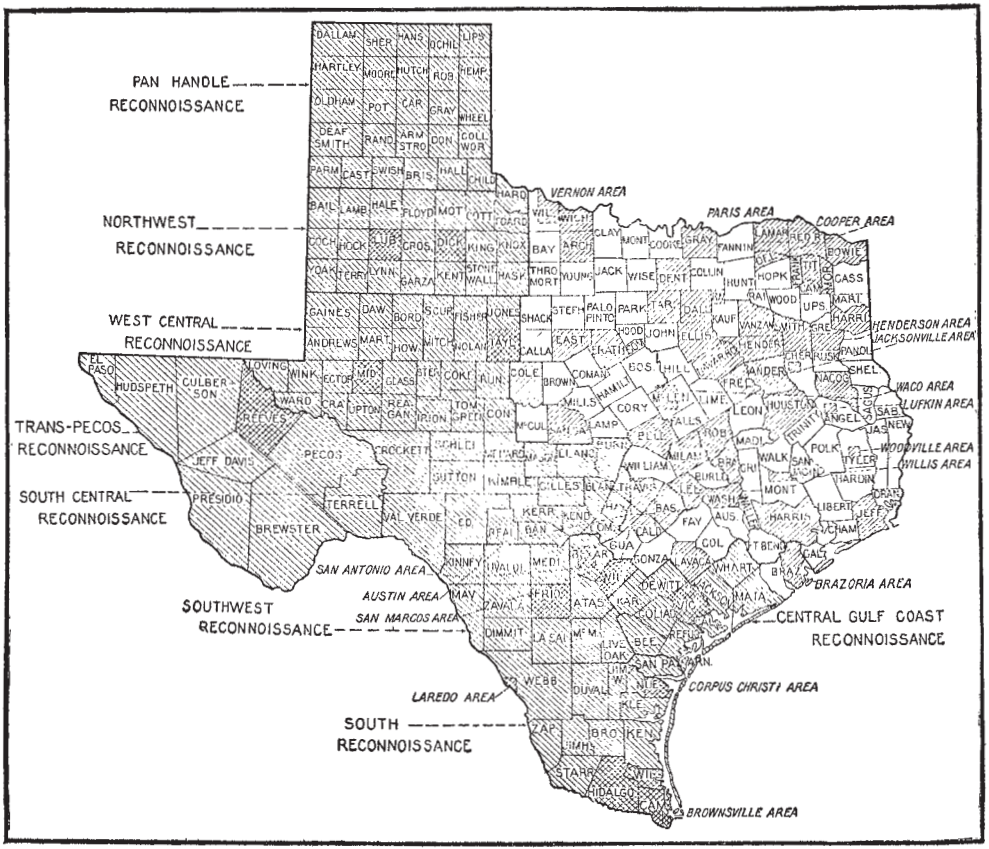

Areas surveyed in Texas, shown by shading.

Detailed surveys shown by northeast-southwest hatching; reconnaissance surveys shown by northwest-southeast hatching; areas covered in both ways shown by crosshatching.

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