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Soil Survey

Zavala County Texas

By
HOWARD M. SMITH, in Charge
M. H. LAYTON, J. T. MILLER, and T. W. GLASSEY
United States Department of Agriculture
and
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Texas Agricultural Experiment Station

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY
In cooperation with the
Texas Agricultural Experiment Station

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SOIL SURVEY OF ZAVALA COUNTY, TEXAS

By HOWARD M. SMITH, in Charge, M. H. LAYTON, J. T. MILLER, and T. W. GLASSEY, Soil Survey Division [1] Bureau of Chemistry and Soils, United States Department of Agriculture, and R. M. MARSHALL, Texas Agricultural Experiment Station

Area inspected by W. T. CARTER, Inspector, District 4

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

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COUNTY SURVEYED

Zavala County is in southwestern Texas, about 25 miles east of the Rio Grande, the international boundary between the United States and Mexico (fig. 1). Crystal City, the county seat, is situated in the south-central part very near the southern boundary of the county. It is about 100 miles southwest of San Antonio and 175 miles northwest of Corpus Christi, the nearest port on the Gulf of Mexico. The county lies in a section of Texas locally known as the Winter Garden District. It is rectangular in shape and has an area of 1,290 square miles, or 825,600 acres.

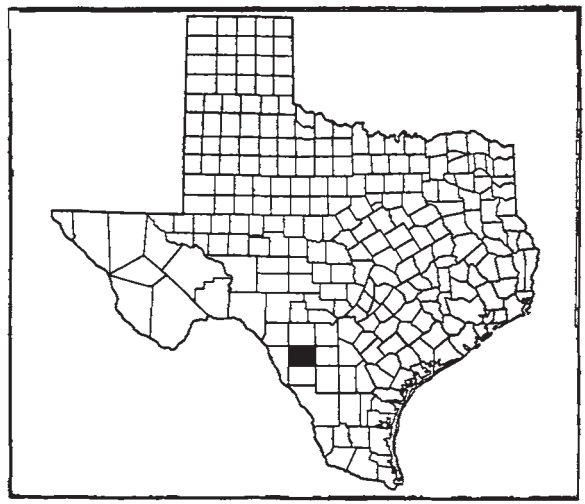

FIGURE 1.—Sketch map showing location of Zavala County, Tex.

[1] The Soil Survey Division was transferred to the Bureau of Plant Industry July 1, 1939.

Zavala County is in the northwestern part of the Rio Grande Plain, a smoothly undulating to gently rolling plain extending southeastward from the Edwards Plateau to the Gulf of Mexico and comprising a broad sloping section of the Gulf Coastal Plain, sometimes referred to as the Rio Grande Embayment. The surface of the county is, in general, smoothly undulating, with some areas of gently rolling relief accentuated in a few places in the northeastern part by moderately sloping low eminences, locally called hills. Here and there are fairly large areas with nearly flat surfaces. The land is dissected by several streams, which follow a southerly course through the county. Owing to the smoothness of the original plain and the unconsolidated character of the underlying geologic material, these streams occupy broad shallow valleys, and most of the upland slopes rise smoothly and gently away from the flood plains. The principal streams—the Nueces and Leona Rivers and Turkey and Chican Creeks—have their origin in or near the Edwards Plateau, which reaches southward to the Balcones Escarpment 30 or 40 miles north of Zavala County. As the streams leave the narrow valleys and canyons of the high limestone plateau, they meander, with a considerably reduced gradient, across the plain through comparatively broad high areas of old alluvium, consisting largely of deep beds of fine earth, in places underlain by beds of rounded gravel that have been deposited during the past ages of periodic deposition.

The Frio River, which also originates near the Edwards Plateau, flows within 1 mile of the northern boundary at its extreme eastern edge, and the extreme northeastern corner of the county is in the flood plain only a short distance from the river bank.

Two types of drainage have developed. East of the Nueces River the plain is slightly more rolling and the drainage pattern is generally dendritic; but in some of the flood-plain areas west of that stream, where, as a rule, the plain is smoother, the surface is cut by many parallel and intersecting channels that carry water only after heavy rains. Lakes and bayous, locally called bayoucas, are in some of the wider flood plains and, like the larger streams, hold water the year around, although even in the larger streams the flow ceases altogether in long dry seasons. All the small streams are intermittent and flow only after rains.

Elevations [2] above sea level range from 580 feet in the southern part on the Nueces River to 964 feet in the northern part at the summit of Batesville Hill a few miles northwest of Batesville. Other elevations are as follows: Crystal City, 568 feet; a point 9 miles west of La Pryor, 868 feet; La Pryor, 750 feet; and a point 3½ miles west of Cometa, 625.5 feet.

The native vegetation, for the most part, is characteristic of a subhumid and semiarid climate, and it is abundant throughout the county. Some large trees grow in the wider flood plains. Those along the stream courses are largely live oak, pecan, elm, cottonwood, and cypress. A rather thick growth of mesquite trees occurs farther back from the larger streams and occupies most of the flood-plain areas in the smaller stream valleys.

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[2] GETZENDANER, F. M. MINERAL RESOURCES OF TEXAS: UVALDE, ZAVALA, AND MAVERICK COUNTIES. Tex. Univ. Bur. Econ. Geol., 140 pp. illus. 1931.

In the upland areas there is a fairly thick growth of native grasses, most of which are rather nutritious. For a long time these grasses have been the basis for successful ranching. The grasses are largely of the grama, buffalo, and mesquite species, with several others of less value. There are two general communities of grasses: the short grasses on the heavier soils, dominated by curly mesquite and red grama (*Bouteloua trifida*), and tall bunchgrasses of the *Andropogon* and other species on the lighter textured sandy soils. Because of the low rainfall in this section, the grasses do not cover the surface completely, except in smooth flat areas where there is little run-off of rain water. The grasses cover from 15 to 50 percent of the surface, according to the character of the soils and moisture conditions.

Practically all of the upland areas are occupied by a more or less scattered growth of small trees and shrubs, largely of species indigenous to a semiarid climate, which vary in number and kind according to the soils and local soil-moisture relationships. The mesquite is the most widespread small tree and also occurs in the greatest numbers. It grows more thickly on the smooth deep soils of both valleys and uplands, although scattered and stunted trees grow on the very thin sloping soils having a very low moisture content. The principal shrubs are blackbrush (*Acacia amentacea*), huisache (*A. farnesiana*), guajillo (*A. berlandieri*), black persimmon, locally called Mexican persimmon (*Diospyros texana*), false-mesquite or lamb-brush (*Calliandra eriophylla*), catclaw (*Acacia* and *Mimosa* sp.), soapbush, or guayacan (*Porlieria angustifolia*), lotebush (*Condalia obtusifolia*), whitebrush (*Lippia sp.*), yucca, sangre de drago, or dragon blood (*Jatropha spathulata*), pricklypear and other cacti, and jointfir (*Ephedra* sp.).[3] This brushy growth is very thick in places. The general term for it is chaparral, although in some localities this name is applied only to specific plants.

On some spots where the soils are thin and very dry conditions prevail, small quantities of so-called desert shrubs grow. These are chiefly cenizo (*Leucophyllum texanum*) and creosotebush (*Covillea tridentata*). In places where the soils contain an appreciable excess of salts some herbaceous plants grow, particularly saladillo (*Varilla texana*) and alkali weed (*Selloa glutinosa*) (pl. 1, *A*). Several species of three-awn grass, locally known as needlegrass, grow naturally on light-textured soils, but on most soils these grasses increase at the expense of more valuable short grasses in heavily grazed pastures. The dark smooth flat deep soils, as a rule, are more thickly and heavily covered with shrubs than are the sloping thin soils.

Zavala County, named for Lorenzo de Zavala, a Texas pioneer, was created from Uvalde and Maverick Counties in 1858 and was organized in 1884. Batesville, a village in the northeastern part of the county, was the first county seat; but Crystal City, situated on the railroad in the extreme southern part, became the county seat in 1928.

The general border area of the Rio Grande Plain, of which Zavala County is a part, was from the earliest period of occupancy a livestock domain where the pioneer stockmen grazed their herds over

[3] The botanical names used in this report were supplied mainly by V. L. Cory, range botanist, Texas Agricultural Experiment Station.

the unfenced free range. Both cattle and sheep were raised, and they grazed in roving herds even before the Civil War, especially along the larger streams where water was available. Early ranches were established at Cometa in 1872, on the Leona River at the present site of Batesville in 1875, and at Loma Vista in 1881. These ranch settlements comprised permanent headquarters of stockmen who came from older settled parts of the region. As livestock raising became more stabilized, in the early seventies, large tracts of land were acquired under private ownership, and much of the range was enclosed within barbed-wire fences. The extension of a railroad into the county in 1908 and the recognition of the possibilities of irrigation of farm lands in particularly well favored sections about this time encouraged settlement by farmers.

According to the 1930 census, the county has a population of 10,349, more than one-half of whom live in towns. A very large number—7,660—of the inhabitants are Mexicans. Crystal City is the principal town and the county seat, and, according to the United States census for 1930, it has a population of 6,609. La Pryor, the second largest town, is in the northern part of the county and has only about 700 inhabitants. Batesville, Loma Vista, Cometa, and Del Monte are merely community centers. Crystal City and La Pryor are the chief shipping centers for winter vegetables and other agricultural products.

The San Antonio, Uvalde, & Gulf Railroad extends through the central part of the county from north to south, near the valley of the Nueces River. It traverses farming areas of smooth soils that are highly suited to crops and have available supplies of water for irrigation, both from wells and streams. United States Highway No. 83, a hard-surfaced road, parallels the railroad and affords motor transportation to other highways that connect the important market centers of Texas. Graveled and graded dirt roads connect the chief farm communities and ranches. Many roads in the thinly settled parts and on the ranches are mere trails but are easily traveled by motor vehicles, except in wet weather. The road and railroad facilities are adequate for the satisfactory marketing of all the agricultural products.

The vegetables produced are largely for northern winter markets. They are packed and iced locally and shipped expeditiously in truck, express, and carload lots. Most of the cattle are shipped to northern livestock markets for feeding or to other areas for continued grazing, and some are sent to slaughterhouses in various meat-packing centers.

All communities and towns are connected by telephone, and many privately owned lines reach the farm homes and ranch headquarters. The towns and communities are well supplied with public schools. There are churches in Crystal City, La Pryor, and Batesville.

The rural homes are small, but on the irrigated farms and on some of the ranches they are, as a rule, comfortable and are equipped with modern conveniences. Many of the dwellings of the Mexican laborers are very simple, many of them rather primitive. The principal towns and some farm homes have electric service and natural gas for fuel.

An ice manufacturing and storage plant at Crystal City provides ice for the refrigeration of freight cars carrying vegetables. A cot-

ton gin is located at La Pryor. A small plant for canning spinach is in Crystal City.

The chief natural resources that have been developed for industry are natural gas; gravel, sand, and caliche for building and road surfacing; and the surface and underground waters, which are useful for irrigation.

CLIMATE

Zavala County is within the warm temperate semiarid region of the United States. The climate is characterized by long warm summers and short mild winters. Periods of extreme heat occur during summer, but they are moderated by the Gulf breezes, especially at night. Periods of clear weather with cold or freezing temperatures, short cloudy, rainy, or foggy spells, and longer periods of warm pleasant weather characterize the winters. The climate is continental, though it is modified by winds from the Gulf of Mexico.

The rainfall of about 21 inches a year generally is insufficient for successful farming, except on some soils where certain crops are able to withstand dry conditions and produce yields in most years. Such soils are mostly in the eastern part of the county, where the precipitation is slightly heavier than elsewhere. In many years the precipitation, which occurs only as rainfall, is not well distributed throughout the seasons. Ordinarily it is heaviest in spring, summer, and fall. The precipitation in winter generally is in the form of light showers over extended periods with only a small total rainfall. The summer precipitation is in the form of more or less local, frequently torrential, rainstorms. Occasionally freshets and floods occur in spring and early fall. Some of the rainfall is impounded in earth reservoirs, and thus a considerable supply of water is made available in places for livestock and for the irrigation of some crops.

The climate is favorable for a widely diversified agriculture and is especially suited to the production of winter vegetables, which are grown largely for northern markets. By irrigation two or three crops may be grown on the same land in a year. Forage crops can be grown under irrigation at any time during the year, but frequently irrigation is unnecessary in the spring. Tillage of the land, except on the heavier soils when wet, is possible at any time of the year.

The raising of beef cattle is facilitated by the long grazing season, the abundance of nutritious grasses, and the mildness of the winters, which, as a rule, are seldom so severe as to necessitate shelter for livestock.

According to the records of the Weather Bureau station at La Pryor, the average date of the latest killing frost is March 1 and the average date of the first is November 28, giving an average frost-free season of 272 days. The latest frost recorded was on April 5 and the earliest on October 30. At the Texas Agricultural Experiment Station near Winter Haven, Dimmit County, the average annual evaporation from an open tank is 61.34 inches. Snow and hail are very rare.

Table 1, compiled from records of the Weather Bureau station at La Pryor, in the northwestern part of the county, gives the normal monthly, seasonal, and annual temperature and precipitation, which are representative of conditions in Zavala County.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at La Pryor, Zavala County, Tex.*

[Elevation, 750 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	52.2	88	17	0.87	0.00	0.96
January	51.2	89	10	1.00	.70	3.84
February	56.6	98	14	.95	.18	1.30
Winter	53.3	98	10	2.82	.88	6.10
March	63.0	99	20	1.16	.04	2.55
April	70.2	103	26	2.46	.00	2.19
May	76.9	111	40	2.53	1.76	3.59
Spring	70.0	111	20	6.15	1.80	8.33
June	82.9	109	46	2.73	1.36	5.28
July	84.8	107	60	1.93	.77	6.26
August	85.2	111	57	1.73	.97	1.62
Summer	84.3	111	46	6.39	3.10	13.16
September	79.8	105	44	2.34	.40	6.16
October	70.7	100	24	2.28	.20	7.22
November	59.7	97	22	.96	.13	1.04
Fall	70.1	105	22	5.58	.73	14.42
Year	69.4	111	10	20.94	6.51	42.01

AGRICULTURAL HISTORY AND STATISTICS

The raising and grazing of beef cattle was the first and still is the leading agricultural enterprise. The nutritious native grasses and browse plants, the mild climate, and the available water in the several streams make this county and adjoining counties well suited to the raising of range livestock, including cattle, sheep, and goats. With the introduction of barbed-wire fencing into the country in the eighties and the limitation of grazing to ranches under private ownership, improvements were initiated in breeds of livestock and in methods of raising range livestock. The gradual westward encroachment of dry farming and livestock farming reached the eastern border of the county. In the eastern part, on soils with the more favorable moisture conditions, certain crops that withstand droughty conditions are grown, and some farm livestock are grazed and fed on forage and grain sorghums produced without irrigation. Occasional droughts, however, not only render extensive dry farming hazardous but also cause such a shortage of native grasses, shrub forage, and water that livestock can no longer be grazed. It then becomes necessary to feed the livestock or move the animals to other grassland.

The incidental production of small quantities of feed crops and other products by the early settlers revealed the fact that large bodies of smooth productive lands were suited to growing crops and so situated that irrigation water could be applied readily. In 1876 an irrigation company was formed, a dam was constructed near Bates-

ville on the Leona River, and about 500 acres of flat alluvial land were placed in cultivation and irrigated from the stream. Records[4] indicate that good yields of corn, oats, hay, cotton, sorghum, fruits, and vegetables were obtained. Corn yielded 35 bushels and cotton 1 bale to the acre.

No great interest in farming or irrigation was shown until 1907 or 1908, when the Cross S and Seven D ranches, which included more than 100,000 acres, were subdivided into farms and sold to settlers. It was known, however, that artesian water was available. In some of the wells there was a flow of water, and in others pumping was required to lift the water to the surface. As farms were settled, irrigation became general from the Nueces River and from natural lakes of the river bottoms, as well as from the artesian wells, which supplied a large quantity of good water. The railroad was built through the county in 1908, and the transportation thus afforded gave an impetus to the settlement and development of farming. The more extensive areas devoted to irrigation farming were developed along the Nueces River and near Crystal City, Cometa, and La Pryor.

The principal crops grown under irrigation are winter truck crops, of which a considerable proportion at one time was onions, but later spinach became the leading crop. Various other truck crops are grown successfully but mainly on a smaller scale. It is reported locally that nearly 4,000 carloads of spinach were shipped from Crystal City in the winter of 1931–32.

According to the United States census of 1880, 6.4 percent of the total land area was in farms, which averaged 2,624 acres in size. In 1935, 90.5 percent of the land was in farms, which had an average size of 2,619 acres. The total number of farms in 1935 was 298, of which 122 were less than 140 acres in size, whereas 93.9 percent (732,535 acres) of the farm land was taken up by 60 farms or ranches averaging 12,209 acres in size. It is evident from this distribution that most of the land still is used for grazing cattle on ranches and that a comparatively small proportion is used for the production of farm and truck crops.

The value of all farm crops produced in 1929, including field and orchard crops, vegetables, and farm gardens, was $1,277,625. Of the 18,153 acres from which crops were harvested that year, vegetables, with a value of $1,150,833, were produced for sale on 11,132 acres. The principal vegetables grown were spinach, with a value of $657,324, grown on 8,226 acres on 45 farms; dry onions, valued at $432,872, grown on 2,251 acres on 43 farms; green onions, valued at $23,981, grown on 105 acres on 2 farms; tomatoes, valued at $4,960, grown on 52 acres on 15 farms; and peppers, valued at $3,102, grown on 51 acres on 6 farms. Other vegetables and truck crops grown on a smaller scale for market include beans, beets, cabbage, cantaloups, carrots, eggplant, and watermelons. General crops included 3,805 acres in cotton; 1,753 acres in sorghums for silage, hay, and fodder; 742 acres in corn for grain; 334 acres in sorghums for grain; and 137 acres in other hay.

According to the census, 34,820 acres, or 4 percent of all the land in the county, represented cropland in 1934, and crops were harvested

[4] TAYLOR, THOMAS U. IRRIGATION SYSTEMS OF TEXAS. U. S. Geol. Survey Water Supply and Irrig. Paper 71, 137 pp., illus. 1902.

from 23,775 acres on 168 farms, of which 19,616 acres on 88 farms were irrigated. Vegetables for sale were harvested from 17,236 acres on 96 farms. About 6,000 acres were devoted to general farm crops in 1934, including 2,186 acres in corn for grain; 1,816 acres in sorghums for grain; 836 acres in cotton; 793 acres in sorghums for silage, hay, and fodder; 154 acres in other hay; and 50 acres in oats. Some of these crops were produced under dry farming, largely on the sandy soils in the eastern part of the county. Other crops grown on a small scale on some farms are broomcorn, dry beans, cowpeas, and peanuts.

Fruits, berries, and grapes are grown in a small way on many farms, largely for home use or experimentally. In 1930, 145 acres were devoted to orchards, vineyards, or nut trees on the 48 farms reporting. In 1935, 55 farms reported a total of 291 acres in these plantings. The principal fruits are peaches and plums, and a few apples and pears are grown. In 1935 there were 732 bearing peach trees and 488 bearing plum and prune trees. Citrus fruit trees grow well and produce good fruit, but injury sustained by occasional cold spells discourages the commercial production of these fruits. In 1935 there were 991 orange trees of bearing age on 37 farms and 372 grapefruit trees of bearing age on 13 farms. Satsuma oranges are being grown successfully on some farms and appear to give promise of becoming a successful commercial fruit. Figs and grapes in the small plantings grow well and produce good yields. Native pecan trees grow in parts of some of the stream valleys and yield well. Some plantings of pecans have been made, and the trees generally are growing well. Blackberries, dewberries, and strawberries are grown successfully in a few small plantings. Many fruit trees are injuriously affected by cotton root rot and various other plant diseases and insects.

Table 2 gives the number and value of livestock on farms and ranches in census years.

TABLE 2.—*Number and value of livestock on farms and ranches in Zavala County, Tex., in stated years*

Livestock	1880 [1]	1890 [1]	1900		1910		1920		1930		[1] 1935
	Number	*Number*	*Number*	*Value*	*Number*	*Value*	*Number*	*Value*	*Number*	*Value*	*Number*
Cattle	3,284	32,726	26,847	(1)	24,969	$391,422	39,803	$2,223,407	26,392	$1,204,577	41,222
Goats	------	------	2,050	(1)	1,199	2,124	1,558	8,384	20,020	79,149	11,912
Horses	331	1,951	1,256	(1)	1,146	46,514	1,221	80,192	1,005	42,020	990
Mules	14	64	123	(1)	192	16,575	654	68,198	611	39,663	469
Sheep	7,046	14,722	3,739	(1)	415	857	68	835	1,395	7,924	3,897
Swine	134	1,233	953	(1)	1,396	4,592	1,921	30,799	405	4,385	769
Poultry	668	4,322	2,828	$839	2,978	983	9,510	10,148	[2] 10,279	[2] 6,990	[2] 11,808
	Hives	*Hives*	*Hives*		*Hives*		*Hives*		*Hives*		*Hives*
Bees	------	------	3,627	9,805	1,883	9,174	2,207	18,524	3,237	14,081	------

[1] Value not reported.

[2] Chickens only.

The livestock on small farms includes a few work animals and poultry, cows, and swine, required to supply home needs. Many farms, however, have an insufficient number for this purpose, and others produce a surplus, which is sold locally. Livestock raising and grazing utilize the major part of the land, and large numbers of cattle and goats and some sheep are raised and grazed on the range on large and small ranches.

The cattle are chiefly Hereford grade animals; the sheep, Merino grades; and the goats, mixed or Angora breeds. Some dairy cattle of the Jersey breed are kept near the large towns, for producing milk for the local markets.

The 85,911 pounds of mohair and kid hair clipped and 6,427 pounds of wool shorn in 1929 were valued at $36,942 and $1,671, respectively. The value of dairy products sold was $14,205, and the production of milk was 180,927 gallons. Poultry is raised chiefly for home use. Some is sold locally, and in 1929 the total value of poultry products produced was $33,110. Most of this value represents the 80,708 dozen chicken eggs produced and the 16,140 chickens raised. Honey is an important product, as the native shrubs afford a good source for this product. In 1929 the honey was valued at $12,653. In 1934 the production of milk increased to 274,129 gallons; wool shorn increased to 17,197 pounds; the number of chickens raised increased to 13,822; whereas the goat hair clipped decreased to 53,049 pounds and chicken eggs produced to 69,287 dozen.

The expenditure for commercial fertilizers in 1929 was $18,035, or an average of $751.46 for each of the 24 farms reporting. Some fertilizers are used on truck crops, especially onions. The use of fertilizers is not an established practice, and its value is not as yet determined.

Most of the farm laborers are Mexicans who work largely in crews, especially in clearing land, planting, and harvesting. Farm labor generally is rather plentiful. Truck crops frequently are sold in the field to buyers who harvest, pack, and transport the products with crews of laborers managed by a labor contractor. In 1929, labor was hired on 180 farms at a total expense of $409,825, or an average of $2,276.81 a farm reporting.

Of the 298 farms in the county in 1935, owners operated 63.4 percent, tenants 33.6 percent, and managers 3 percent. Under dry-farming contracts, the tenant pays one-third of the grain and other feed crops and one-fourth of the cotton as rental; the owner furnishes the land and buildings and the tenant the labor, work animals, and machinery. If the owner furnishes everything except the labor, the tenant furnishes the labor and pays one-half of all crops as rental. In truck farming under irrigation several special contracts are in use. Under some the buyers finance the crops, the tenant or farmer furnishing labor and tools. Little farm land is rented for cash, but, under such contracts, rentals range from $6.50 to $12 an acre. Ranch lands lease at the rate of 25 to 50 cents an acre a year. The average value of land and buildings was $28,367 a farm and $18.68 an acre in 1930 and $30,844 a farm and $11.78 an acre in 1935.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers, or horizons, called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil,

is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [5] and its content of lime and salts are determined by simple tests.[6] Drainage, both internal and external, and other external features, such as relief, or lay of the land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, special emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics soils are grouped into mapping units. The three principal ones are (1) series, (2) type, and (3) phase. Areas of land, such as coastal beach or riverwash, that have no true soil, are called (4) miscellaneous land types.

The most important group is the series, which includes soils having the same genetic horizons (developed layers), similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus, the series includes soils having essentially the same color, structure, and other important internal characteristics and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Thus, Uvalde, Monteola, and Frio are names of important soil series in this county.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Uvalde silty clay loam and Uvalde silty clay are soil types within the Uvalde series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is generally the soil unit to which agronomic data are definitely related.

A phase of a soil type is a variation within a type, which differs from the type in some minor soil characteristic that may have practical significance. Differences in relief, stoniness, and the degree of accelerated erosion frequently are shown as phases. For example, within the normal range of relief for a soil type there may be areas that are adapted to the use of machinery and the growth of cultivated crops and others that are not. Even though there may be no important difference in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such instances the more sloping parts of the soil type may be segregated on the map as a sloping or hilly phase. Similarly, soils having

[5] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, higher values indicate alkalinity, and lower values indicate acidity.

[6] The total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthalein solution is used to detect a strong alkaline reaction. Lime ($CaCO_3$) is detected by application of dilute acid.

differences in stoniness may be mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, and miscellaneous land types, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS[1]

The soils of Zavala County are representative of the northwestern part of the Rio Grande Plain, which covers all or parts of several counties in the semiarid section of southwestern Texas. Much of the county is occupied by smooth land with deep and moderately to highly productive soils, although, locally, many smaller widely scattered bodies are unsuited to cultivation. The soils have developed from unconsolidated or only slightly consolidated beds of clays and sandy clays, with some soft sandstone and shaly material. The formations are of sedimentary materials and differ widely. Some highly siliceous beds have weathered into sandy soils; shales and clays have developed into heavy or moderately heavy dark soils, some of which are highly calcareous; and old alluvial deposits of outwash calcareous silty materials overlying thick beds of rounded gravel have formed into deep permeable productive soils. The formations that underlie and outcrop on the Gulf Coastal Plain Province are of the Eocene and Quaternary periods. Some areas of red sandy soils have developed from the Carrizo sand formation, which is the source of the plentiful underground water used for irrigation from wells.

Although many of the soils are inherently fertile, and if irrigated would be suited to many crops, they remain largely in native pasture, because the rainfall is insufficient to allow systematic dry farming. Certain crops that withstand dry conditions, however, are grown to a small extent in the eastern part, and farm and truck crops are produced on a small proportion of the land. The cultivated soils either have good moisture-holding capacity for dry farming or are favorably situated for the application of the irrigation water from both wells and streams. The advance of truck farming into the county has been favored especially by the moderate winter temperature.

Most of the native grasses and shrubs are highly suitable for grazing and browsing for livestock, and the warm winter requires no shelter for the animals. These two factors reduce markedly the cost of livestock raising.

Most of the dry farming is carried on near La Pryor, Batesville, and Loma Vista. The crops more generally grown are corn, sorgo, grain sorghums, Sudan grass, and cotton. Some of the same crops are grown elsewhere under irrigation. The soils best suited to dry farming, because of their more favorable moisture relationships, are the fine sandy loams of the Duval, Webb, and Crystal series. The

[1] Zavala County adjoins Frio County, which was surveyed in 1929. In places the soils as mapped in Zavala County do not have the same names as those mapped in the adjoining county, and the boundaries of the areas do not coincide at all points. This is due, to more precise definition of some of the soil series and types and the splitting of some older series and types into two or more.

loose surface soils collect and absorb a large proportion of the rainfall, and the subsoils retain much of the water until it is required by the crops. The soils of the Uvalde and Frio series, which occupy smooth, nearly flat land, are also highly suited to these crops, but, as they are more productive and more readily irrigated, they are used more extensively for the production of truck crops.

The mild climate, the depth, fertility, and adaptability of the soils, the availability of water for irrigation, and the good facilities for marketing are factors that have favored rapid expansion of the production of winter truck crops, especially spinach and onions, and, to less extent, tomatoes, peppers, and several other vegetables. The heavier soils—silt loams, silty clay loams, and clay loams—appear to be best suited to spinach, but the other vegetable, fruit, and berry crops do well, some much better, on the sandy soils where they can be irrigated. Most of the larger areas devoted to truck crops are in the vicinity of Crystal City, in the Nueces River Valley, and around La Pryor and Cometa. Growers state that the fine sandy loams of the Webb, Crystal, and Maverick series appear best suited for early production, but that the heavier soils of the smooth uplands, such as Uvalde silty clay loam, Monteola clay, and Monteola clay loam, are the best soils for late crops of onions. Tomatoes also do well on the heavy soils and the fine sandy loams, but as yet Duval fine sandy loam is not used for truck crops, as it is not under irrigation.

For convenience of discussion, the soils of Zavala County have been arranged in the following five groups, based largely on soil characteristics, but having some significance in land use and productivity: (1) Dark-colored heavy-textured soils of the smooth uplands, (2) soils from alluvial materials, (3) reddish-brown sandy soils, (4) brown sandy soils, and (5) soils and land types unsuited for cultivation.

In the following pages the soils are described in detail, and their agricultural relationships are discussed; their location and distribution are shown on the accompanying soil map; and their acreage and proportionate extent are given in table 3.

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

Soil type	Acres	Percent	Soil type	Acres	Percent
Uvalde silty clay loam	207,552	25.1	Webb fine sandy loam	80,064	9.7
Uvalde silty clay loam, shallow phase	13,120	1.6	Crystal fine sandy loam	9,216	1.1
Uvalde silty clay	33,856	4.1	Crystal fine sand	10,624	1.3
Monteola clay	94,784	11.5	Brennan loamy fine sand	3,200	.4
Monteola clay loam	67,520	8.2	Brennan fine sandy loam, shallow phase	6,912	.8
Frio silt loam	14,912	1.8	Maverick fine sandy loam	16,832	2.0
Frio silty clay loam	7,360	.9	Miguel fine sandy loam	5,888	.7
Frio silty clay loam, depression phase	4,352	.5	Maverick clay loam	27,456	3.3
Frio clay loam	5,888	.7	Maverick clay, saline phase	19,136	2.3
Frio fine sandy loam	384	.1	Maverick clay, gravelly phase	6,208	.8
Guadalupe silty clay loam	2,752	.3	Uvalde gravelly loam	1,216	.1
Leona clay	45,312	5.5	Zapata fine sandy loam	11,456	1.4
Zavala fine sandy loam	9,728	1.2	Zapata gravelly loam	2,432	.3
Zavala clay loam	2,560	.3	Webb gravelly fine sandy loam	53,440	6.5
Duval fine sandy loam	54,144	6.6	Randall clay	192	(1)
Duval fine sandy loam, shallow phase	6,336	.8	Riverwash	768	.1
			Total	825,600	

[1] Less than 0.1 percent.

DARK-COLORED HEAVY-TEXTURED SOILS OF THE SMOOTH UPLANDS

The group of dark-colored heavy-textured soils of the smooth uplands includes Uvalde silty clay loam; Uvalde silty clay loam, shallow phase; Uvalde silty clay; Monteola clay; and Monteola clay loam. Their combined area is one-half of that of the county. All these soils have comparatively dark heavy calcareous surface soils over light-colored calcareous clay subsoils. The Uvalde soils lie on smooth high benches or outwash plains and the Monteola soils on gently undulating uplands. In their native state they are grasslands.

The Uvalde soils have heavy smooth-textured calcareous surface soils ranging from medium gray to almost black with only a slight brown tinge. The subsoils are light-gray or yellowish-gray highly calcareous clay, fairly permeable to water and roots. These soils are developed on high-lying alluvial plains, from calcareous clay washed from the soils and limestone formations of the Edwards Plateau, and in places are underlain at great depths by beds of gravel. When provided with sufficient moisture, they are physically and chemically well suited to the production of many crops. General farm and truck crops do well, and large areas are used for the production of winter-grown vegetables, especially spinach. Ground water is pumped from wells for irrigation.

The Monteola soils are similar to the Uvalde soils but are somewhat darker colored and have somewhat heavier textured and less pervious subsoils. The surface soils are heavy textured, calcareous, and range in color from dark brownish gray to black. The subsoils and substrata are heavy-textured slowly pervious light-gray or yellowish-gray clay or shaly clay. These soils are productive where supplied with water for irrigation, and winter-grown vegetables are the most important crops. Large areas, however, have no readily available water supply, and as a result the land is used largely as range for livestock.

Uvalde silty clay loam.—The surface soil of Uvalde silty clay loam is dark grayish-brown or dark-gray calcareous silty clay loam, about 12 inches thick. The color of this material when thoroughly air-dried is distinctly gray, but when wet a slight brown shade is apparent. The cultivated surface soil is granular and readily works into a mass of small particles, leaving the material friable. This grades into slightly lighter colored material—grayish-brown or yellowish-brown calcareous granular silty clay or silty clay loam. This material, in turn, grades into yellowish-gray highly calcareous crumbly permeable clay. Soft and hard lumps and concretions of white calcium carbonate appear in the subsoil at a depth ranging from 2 to 4 feet. This material reaches to a depth of several feet and makes up a considerable proportion of the subsoil mass. The organic-matter content is not large. Despite the heavy texture of the surface soil and subsoil, the structure and consistence are such that cultivation is easy and plant roots penetrate deeply. In places where the surface is slightly depressed and drainage is very slow, the surface soil is darker than elsewhere.

Uvalde silty clay loam is by far the most extensive soil of the group, but it is not widely distributed. It occurs near the Nueces, Leona, and Frio River Valleys and along the larger creeks. Large bodies are near Crystal City, La Pryor, and Batesville.

The land is nearly flat, although the slope is sufficient for the application of irrigation water. Surface drainage is slow but adequate for the crops grown, and underdrainage is good. The soil has developed on old deep beds of alluvium, which consist mostly of calcareous silty clay over beds of rounded gravel. The material has been transported by water from the soils and limestone formations of the Edwards Plateau. These beds comprise smooth terraces, which lie from a few to many feet above the overflow level of the present flood plain.

Uvalde silty clay loam in its natural state is grassland, on which a more or less thick growth of small trees and shrubs, characteristic of a semiarid climate, has encroached. The grass cover is fairly thick in places and consists of curly mesquite, buffalo grass, certain species of grama, and some tobosa grass. There is a growth of scattered mesquite trees and of such shrubs as guajillo, soapbush, false-mesquite, persimmon, lotebush, and others.

Although much of this soil is included in ranches and is used for grazing and browse for livestock, a considerable proportion is cultivated. It is smooth, lends itself well to irrigation, and lies near a good supply of water for that purpose, either from streams or from wells from which water is pumped. Small fields are dry farmed, and the principal crops thus grown are cotton, corn, grain sorghums, sorgo, and other feed crops. The crops grown under irrigation are chiefly spinach and onions and, to less extent, various other vegetables for winter markets. It is reported locally that under dry farming corn yields from 18 to 25 bushels an acre in different parts of the county, the higher yields being obtained in the eastern part where rainfall is slightly higher. Similarly, sorgo produces 2 or 3 tons of hay to the acre, and Sudan grass, 1 or 2 tons. Grain sorghums give corresponding yields of forage. As this crop is cut, bundled, and fed without threshing, grain yields cannot be measured. Farmers state that corn under irrigation yields an average of about 40 bushels an acre, sorgo hay 8 tons, spinach 250 bushels, and onions from 150 to 250 crates or bushels. On many large farms ranging from several hundred to 2,000 acres in size, spinach is produced almost exclusively, and Uvalde silty clay loam is one of the preferred soils for this crop. Some tomatoes are grown under irrigation, and yields of 1½ to 2½ tons to the acre are reported. Many other vegetables and truck crops do very well under irrigation, but comparatively small quantities are grown. Some of those grown successfully at various times for the winter markets are cabbage, peppers, broccoli, carrots, eggplant, beets, cucumbers, cantaloups, okra, and lettuce.

Uvalde silty clay loam, shallow phase.—Uvalde silty clay loam, shallow phase, is a thin slightly sloping soil occurring in small narrow strips along gentle to moderate slopes of drainageways, which pass through large areas of the typical soil. It differs from the typical soil in that the soil layers appear thinner and lighter colored, and the surface soil contains less organic matter.

The 10-inch surface soil is grayish-brown calcareous silty clay loam, becoming gray when dry. It grades into grayish-brown or gray calcareous silty clay, which, below a depth of about 20 inches, passes into mottled yellow and gray silty clay containing considerable quantities of soft calcium carbonate. This layer is several feet thick,

and probably, in most places, little change in the material takes place to a depth of many feet, except that the content of calcium carbonate decreases.

This soil is not very extensive. Surface drainage is rapid, and the land is slightly eroded. The native vegetation is similar to that on the typical soil, but the grass cover is much thinner because of lack of moisture due to rapid run-off of rain water.

Very little of this soil is in cultivation, as most of it is too sloping for satisfactory irrigation, and it is not highly productive, owing to erosion.

Uvalde silty clay.—The surface soil of Uvalde silty clay is dark-gray or dark brownish-gray calcareous silty clay, about 12 inches thick. It dries to a hard mass but separates to small and fine clods, and, by careful cultivation under favorable moisture conditions, the material can be worked into a mellow condition. The surface soil grades into dark-gray or grayish-brown calcareous clay, which is rather heavy but fairly permeable and crumbly. This material passes, at a depth of about 34 inches, into yellow silty clay containing fine white chalky particles of calcium carbonate. The clay is mealy and crumbly when moist. The soil material reaches a depth of 5 feet or more where it rests on thick beds of rounded gravel. In places, especially in very flat smooth areas, the surface soil is very dark, and, when moist, is nearly black.

Uvalde silty clay is more or less associated with areas of Uvalde silty clay loam on the flat areas near the larger stream valleys. It is not a very extensive soil, but some areas are fairly large.

The surface is nearly flat but in most places has sufficient slope to allow the ready application of irrigation water. The soil occupies large flats of old alluvial terraces largely made up of calcareous clays washed from soils of the Edwards Plateau and deposited over the valleys on former flood plains, which now lie high above overflow. Surface drainage is slow, and underdrainage is very slow because of the heavy clay subsoil, which, although not a claypan, does not allow free passage of water downward.

The native vegetation is similar to that on Uvalde silty clay loam. In places, however, the grass cover is thicker than on that soil, and in other places the mesquite trees and shrubs are large and thick. In general, the growth is dense.

It is reported that spinach, the chief crop, sometimes turns yellow after heavy applications of irrigation water, perhaps because of poor underdrainage. Under the best conditions spinach yields about 300 bushels to the acre. About the same crops are grown with about the same results as on Uvalde silty clay loam. Uvalde silty clay is more difficult to cultivate than Uvalde silty clay loam, and as drainage, especially underdrainage, is slow, the silty clay, though inherently highly fertile, is not so well adapted to truck crops as the silty clay loam.

Monteola clay.—The surface soil of Monteola clay is dark-gray or black calcareous heavy clay, which is very plastic and tenacious when wet but separates naturally into coarse grains and fine irregular clods on drying. This grades, at a depth of about 10 inches, into grayish-brown heavy calcareous clay containing, below a depth of 20 inches, some yellow spots and fine white concretions, and at a depth of 28 inches this material grades into light yellowish-brown or brownish-

gray calcareous crumbly clay containing calcium carbonate concretions. This layer with the accumulated calcium carbonate ranges from 1 to 2 feet in thickness and rests on yellowish-brown calcareous clay or shaly clay, which contains but few segregated particles of calcium carbonate but has some soft particles of gypsum.

The surface is smooth, and the virgin soil has a microrelief of round shallow depressions a few feet wide, known as hog wallows. In the depressions the soil is very black, and not everywhere is the surface soil calcareous; but the soil material in the mounds between the depressions is dark brown and calcareous.

This soil is extensive and occurs in large smooth bodies throughout the central and western parts of the county. The slope allows easy application of irrigation water. Both surface drainage and underdrainage are slow, owing to the heavy texture of the subsoil. The soil has developed from calcareous clays and shaly clays, with some interbedded layers of limestone in places.

The soil supports a heavy growth of curly mesquite, grama, and other short grasses; some mesquite trees; and shrubs of soapbush, whitebrush, lotebush, and others.

The soil is productive but is difficult to cultivate because of its massive consistence. It is cultivated to a considerable extent in places and irrigated from wells. The principal crops are winter-grown vegetables, chiefly spinach; and some onions, broccoli, and other vegetables are grown for market. Corn, grain sorghums, and sorgo are the chief farm crops. It is reported that spinach yields from 250 to 300 bushels, onions 230 bushels, corn 40 bushels, and sorgo hay 8 tons. Because of the heavy, slowly permeable character of the surface soil and subsoil, care must be used in applying irrigation water. Plants turn yellow either because of excess water or the concentration of soluble salts in places. Water should be applied so that the soil will not dry out and become too compact, as it is reported that this condition sometimes causes onions to be misshapen and prevents them from developing properly.

Monteola clay loam.—Monteola clay loam has much the same profile as Monteola clay, except that the surface soil is less heavy textured than that of Monteola clay. The surface soil is black or dark-gray calcareous clay loam, ranging from 6 to 15 inches in thickness, and averaging about 10 inches thick. In places the line of contact between the surface soil and subsoil is decidedly wavy. The subsoil is dark-gray calcareous clay, which grades into yellowish-gray compact and dense clay below a depth of 20 inches. At a depth of 30 inches this material passes into light yellowish-brown calcareous clay containing some concretions of calcium carbonate and some particles of gypsum. Below a depth of about 50 inches the material is yellow shaly clay containing fragments of gypsum.

Monteola clay loam is a rather extensive soil occurring in the smooth uplands in the central and western parts of the county. The land is smooth, and drainage is moderately slow. The soil is developed from more or less calcareous clay and shaly clay, and the underlying formation is heavy textured and allows only very slow underdrainage.

The native growth comprises a thick cover of red grama grass, mesquite grass, bunchgrasses, and numerous but scattered mesquite trees and shrubs similar to those growing on Monteola clay.

This is a deep and fertile soil. Although it is better suited to cultivation under irrigation than Monteola clay, not much of the land is devoted to crops, partly because of the isolation of some areas within large ranches and also because some areas lie west of the land that is underlain by a good and plentiful supply of water for irrigation. Where the soil is cultivated, about the same crops are grown and the same yields are obtained as on Monteola clay. Cultivation is made easier and drainage is more favorable on this soil than on Monteola clay by removing excess irrigation water. More satisfactory crops, therefore, of both spinach and onions are obtained on it than on the clay.

SOILS FROM ALLUVIAL MATERIALS

The soils developed from alluvial materials include Frio silt loam; Frio silty clay loam; Frio silty clay loam, depression phase; Frio clay loam; Frio fine sandy loam; Guadalupe silty clay loam; Leona clay; Zavala fine sandy loam; and Zavala clay loam. They cover 11.3 percent of the area of the county. These soils consist of alluvial materials comprising the bottom-land areas or flood plains along the streams. Although they have a wide range in texture, these soils are related in structural characteristics, soil and soil-water relationships, and their comparatively high content of plant nutrients. No distinct profile has developed as yet in these soils. They consist of materials eroded and transported by water from areas of upland soils. Most of them are valuable, highly fertile soils, suited to many crops, and, in many places, favorably situated for the application of irrigation water. Some of them, therefore, are utilized largely for the production of winter-grown truck crops, especially along the Nueces River. The same uses are made of these soils as of the dark-gray soils of the smooth uplands. Irrigation water is taken mostly from rivers instead of wells, as on the upland soils.

These soils partake to some extent of the characteristics of the soils from which the alluvial materials were derived. The Frio soils consist of brown or brownish-gray calcareous heavy materials transported by streams draining the calcareous heavy upland soils, largely of the Edwards Plateau. Guadalupe silty clay loam is distinguished from the Frio soils, with which it is closely associated, by its light-textured sandy subsoil. Leona clay is black and highly calcareous. The Zavala soils are dark brown, noncalcareous, and occupy the narrow bottom lands along small streams that drain the sandy upland soils.

Frio silt loam.—The surface soil of Frio silt loam is brownish-gray or grayish-brown calcareous silt loam. It grades, at a depth ranging from 12 to 18 inches, into lighter grayish brown heavy calcareous silt loam. This passes gradually, at a depth of about 24 inches, into yellowish-brown heavy calcareous silt loam, which continues to a depth of many feet.

Fairly large areas and narrow strips of this soil occur on the Nueces River bottom from La Pryor southward. They merge gradually with the very narrow strips of Guadalupe silty clay loam adjacent to the stream and with areas of Frio silty clay loam, depression phase, on the other side toward the upland. This soil is not extensive. Most of the

land has been cleared of the native vegetation, which consists largely of short grasses, mesquite trees, and a fairly thick growth of guajillo, catclaw, and other shrubs. Some native pecan trees also grow on this soil.

Frio silt loam is well drained, easily worked, and productive. Its position is high enough so that overflows are rare, and a large proportion of the land is in cultivation. It is highly esteemed for growing truck crops. Winter truck crops, especially spinach, are grown largely under irrigation from the Nueces River. Spinach yields 250 to 300 bushels an acre. Some corn and other crops are grown in small areas, and yields are very good. The permeability and free underdrainage of this soil render it particularly valuable for irrigated truck crops.

Frio silty clay loam.—The surface soil of Frio silty clay loam consists of brownish-gray or grayish-brown calcareous silty clay to a depth of about 15 inches. This material grades into brown calcareous clay loam, which, at a depth ranging from 3 to 4 feet, passes into yellow calcareous clay loam containing an appreciable quantity of fine sand that extends to a depth of 14 feet or deeper. Frio silty clay loam is very similar to Frio silt loam, but it is slightly heavier in texture and, therefore, is less easily cultivated or drained.

This is not an extensive soil. It occupies narrow areas along the larger streams, especially along the Leona River and along the Nueces River near La Pryor.

The surface of this soil, in general, is flat and, in places, slightly depressed. In most places its position is somewhat lower than that of Frio silt loam. Surface drainage is fair, and underdrainage, although slow, is adequate for good growth of crops. Occasional overflows cover the surface for short periods but are not frequent enough to prevent successful cultivation.

The uncleared areas are covered with a rather heavy growth of short grasses and some trees and shrubs, largely mesquite, false-mesquite, lotebush, whitebrush, guajillo, and catclaw. There are a few pecan trees.

The soil is cultivated to a considerable extent, and the chief crops grown are winter vegetables produced under irrigation for the northern markets. Spinach is the chief crop, and yields are approximately the same as on Frio silt loam. This soil is highly productive and will produce good yields of all the general farm crops, probably somewhat higher yields under irrigation than does Uvalde silty clay loam.

Frio silty clay loam, depression phase.—The depression phase is very similar in profile characteristics to typical Frio silty clay loam, but, in places, the surface soil is slightly darker and the organic-matter content apparently is slightly greater than in the typical soil. The surface soil is grayish-brown or brownish-gray calcareous silty clay loam about 15 inches thick. It grades into calcareous brown clay or silty clay, which, below a depth ranging from 4 to 5 feet, is yellow friable calcareous silty clay.

This soil occurs only in small narrow areas, largely within the Nueces River bottom in low swales near the upland. These swales are, in fact, the lowest parts of the bottom lands. Surface drainage is very slow. Water, either from the adjacent upland slopes or from overflow of the river, stands on the surface for some time.

The native vegetation is similar to that on the typical soil, and, in places, thrifty native pecan trees grow. Some areas of this soil, where associated with Frio silt loam and Frio silty clay loam, are in cultivation. Owing to the difficulty of irrigation without water-logging, this soil is not so desirable for crops as the better drained soils, but it is inherently fertile and suited to the general farm and truck crops commonly grown.

Frio clay loam.—Frio clay loam is similar to Frio silty clay loam and differs from it only in that it contains less silt and more fine sand and, therefore, is somewhat more friable when dry and less sticky when moist. The 12-inch surface soil is grayish-brown or brownish-gray calcareous clay loam. It grades into light-brown or yellowish-brown calcareous silty clay or clay, which continues to a depth of many feet.

This soil occupies smooth nearly flat areas, most of which are along the Neuces River from La Pryor northward, along the Leona River north of Batesville, and in small creek bottoms in the southwestern part of the county. The soil is overflowed occasionally, but drainage is adequate for cultivation. Not much of the land is farmed, however, as it occurs in small widely separated areas outside the well-developed truck-farming section.

Frio fine sandy loam.—The surface soil of Frio fine sandy loam is brown or grayish-brown calcareous fine sandy loam. It grades, at a depth ranging from 15 to 20 inches, into brown or yellowish-brown calcareous fine sandy loam or, in places, fine sandy clay loam.

This soil is of slight extent and occurs mainly along Spurler Creek in the southwestern part of the county. Natural drainage is very good. The land supports a heavy growth of elm, hackberry, live oak, and mesquite trees and various shrubs. The soil is fairly productive and suited to various crops, but little is cultivated, as the areas are very small and most of them outside the irrigated truck-crop sections.

Guadalupe silty clay loam.—Guadalupe silty clay loam is similar in profile to Frio silty clay loam, but the subsoil is, as a rule, more sandy and coarser in texture than the surface soil. The 10-inch surface soil of Guadalupe silty clay loam is dark grayish-brown or brownish-gray calcareous silty clay loam. It grades into brownish-gray calcareous silt loam or clay loam, which, at a depth of about 20 inches, passes into light grayish-brown silt loam or very fine sandy loam.

This soil is of very slight extent. It borders the Nueces River on benches ranging from 200 to 300 feet in width and from 15 to 20 feet above the river at low stage. The areas are overflowed occasionally. The soil lies from 10 to 15 feet lower than the Frio soils, which comprise the greater part of the stream bottom.

Guadalupe silty clay loam supports a growth of fine native pecan trees and a few large live oak, elm, and hackberry trees. The land is not cultivated and is probably better suited to pecans than to any other crop. This is doubtless a moderately productive soil, but it is not cultivated because of the low position and small extent.

Leona clay.—The surface soil of Leona clay is black or very dark grayish-brown heavy calcareous clay from 12 to 16 inches thick. On drying, the material separates into fine granules and fine clods, giving a friable consistence. When very dry, deep cracks form in the soil;

when wet, the material is very sticky. The surface soil grades into grayish-brown, gray, or bluish-gray heavy calcareous clay, which continues downward for many feet.

The general land surface is flat, but the microrelief shows small shallow depressions a few feet wide, which are very similar to the hog wallows of the heavy soils of the prairies farther east. Leona clay occurs chiefly as the flood-plain bottom land along some creeks, locally called bayoucas, in the western part of the county. The flood-plain areas are very narrow in the upper reaches of these streams but become fairly wide in their lower reaches west of Crystal City. Small areas border the Leona River below the point where that river turns eastward, and very narrow strips border some of the small creeks in the eastern part of the county. The total area covered by this soil is larger than that of any other soil in the group. Land along the bayoucas is overflowed frequently and sometimes remains very wet for a long time; elsewhere it is overflowed occasionally. The soil material consists of clay washed from surrounding areas of dark upland soils.

There is a thick growth of mesquite trees, together with guayacan, lotebush, whitebrush, Jerusalem-thorn, locally called retama, and other shrubs. Very little of the land is in cultivation. Farming in the small areas along the bayoucas has been unprofitable, even though the soil is inherently fertile. Cultivation is difficult, and, owing to poor drainage, too much irrigation water stands in the soil, causing certain truck crops to turn yellow.

Zavala fine sandy loam.—Zavala fine sandy loam consists of alluvial soil materials in narrow strips, comprising the flood plains of small streams, that drain the upland sandy soils, largely the soils of the Duval and Webb series. The surface soil is dark-brown fine sandy loam containing sufficient organic matter to impart a somewhat darker color than is characteristic of the adjacent sandy soils of the upland. It grades, at a depth ranging from 8 to 15 inches, into dark-brown fine sandy clay or clay loam, which continues to a depth of several feet. The composition of the subsoil is rather indefinite, owing to the variety of materials deposited by the overflow waters of small streams. The soil is rather friable, and neither surface soil nor subsoil is calcareous.

Zavala fine sandy loam is not an extensive soil, but it occurs in many long narrow strips throughout the county. The land is flat, and occasional overflows after heavy rains cover the surface for a short time.

The native growth consists of coarse grasses, together with some grama and three-awn grasses, and a rather heavy growth of mesquite trees, whitebrush, false-mesquite, catclaw, and pricklypear.

Most of this land is included in cattle ranches and is not farmed. Small areas on some farms operated without irrigation are used to grow grain sorghums, corn, and other feed crops. The soil is fairly productive, and yields are good when the supply of moisture is adequate.

Zavala clay loam.—The 10-inch surface soil of Zavala clay loam is dark-brown clay loam. This grades into brown or grayish-brown fine sandy clay. Neither the surface soil nor the subsoil is calcareous.

This is a very inextensive soil and occurs only in small areas along narrow bottoms of very small streams in the southeastern part of the county. The surface is flat, and overflows occur occasionally. As a rule, however, drainage is good. The vegetation consists of small trees, brush, and some grama and coarse grasses similar to those on Zavala fine sandy loam. The land, practically none of which is cultivated, is in ranches and is used mainly for grazing along with the more extensive soils. It is probably well suited to corn, cotton, grain sorghums, and other feed crops when sufficient moisture is available.

REDDISH-BROWN SANDY SOILS

The reddish-brown sandy soils include Duval fine sandy loam; Duval fine sandy loam, shallow phase; Webb fine sandy loam; Crystal fine sandy loam; and Crystal fine sand. The members of this group have friable or loose surface soils and subsoils ranging from loose sand to heavy sandy clay. They are fairly extensive in the eastern and some of the western sections, where they have developed from sandstone and sandy clay or stratified sand beds. Some of them constitute the outcropping materials of underlying formations that act as a reservoir for the abundant supply of underground water, which is tapped by wells in certain parts of the county.

Members of the Duval series are normally deep, with brownish-red surface soils and red friable subsoils. The material in neither of these layers is calcareous. In the Webb soils the color is less red, being a reddish brown, and the subsoil is much denser than in the Duval soils. The Crystal soils also are reddish brown like those of the Webb series, but the subsoil is friable like that of the Duval soils.

The reddish-brown sandy soils are suitable for growing many kinds of vegetables, fruits, and berries, and they produce moderate yields of the general farm crops. The chief use of these soils is for producing general farm crops by dry-farming methods, but some vegetables are grown under irrigation in winter for northern markets.

Duval fine sandy loam.—Duval fine sandy loam is an extensive soil throughout certain sections of the Rio Grande Plain in southwestern Texas. The surface soil is reddish-brown or brownish-red fine sandy loam, about 10 inches thick. It gives way to dull-red fine sandy clay, which grades, at a depth of about 18 inches, into red fine sandy clay having a slight yellow cast. This material merges, at a depth of 2 to 3 feet, with reddish-yellow calcareous fine sandy clay containing white concretions of calcium carbonate. This horizon is about 3 feet thick. Below is yellow sandy clay, or pack sand, which appears to be disintegrated sandstone. This soil has developed from parent materials consisting of weathered sandstone beds of the Cook Mountain formation. Plate 1, *B*, shows a profile of this soil near Loma Vista.

Duval fine sandy loam occurs in the southeastern part of the county and has an area of 84.6 square miles. The surface is undulating or gently rolling, and drainage is free.

The native vegetation consists of a moderately thick cover of both tall and short bunchgrasses, very little curly mesquite and grama grasses, a scattered growth of mesquite trees, and shrubs of false-mesquite, soapbush, catclaw, yucca, *Jatropha*, blackbrush, guajillo,

pricklypear, and whitebrush in the swales where water accumulates after rains. The native grasses and shrubs afford good summer range for livestock.

Very little of Duval fine sandy loam in this county is cultivated, because of its distance from transportation facilities and towns, and most of it is used for ranching. Small areas in the eastern part are cultivated without irrigation, and this section represents the extreme western limit of dry farming. Cotton, grain sorghums, sorgo, corn, and other feed crops are grown, and yields are good except in extremely dry seasons.

In the counties just east of Zavala County, however, large areas of this soil are cultivated, not only under dry farming but under irrigation. Here, in addition to the farm crops mentioned, many vegetables, peanuts, watermelons, cantaloups, strawberries, and other crops are produced for outside markets. Where more of this soil is cultivated farmers report the following acre yields when moisture conditions are favorable: Cotton, one-fourth to one-half bale; corn, 25 to 35 bushels; and grain sorghums, 20 to 40 bushels. Under irrigation spinach and onions yield from 150 to 300 bushels to the acre. Citrus fruits, especially satsuma oranges, do well in some adjacent counties, although climatic conditions are uncertain and cause losses by freezes.

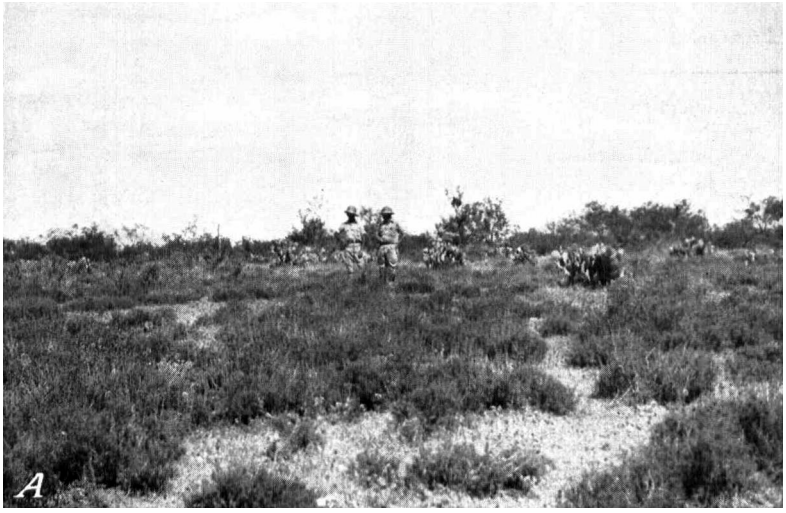
Farmers in irrigated sections of Frio County, which joins Zavala County on the east, have reported that this soil responds well to applications of manures, organic matter, and commercial fertilizers, especially those containing nitrogen and phosphorus, when moisture conditions are favorable.

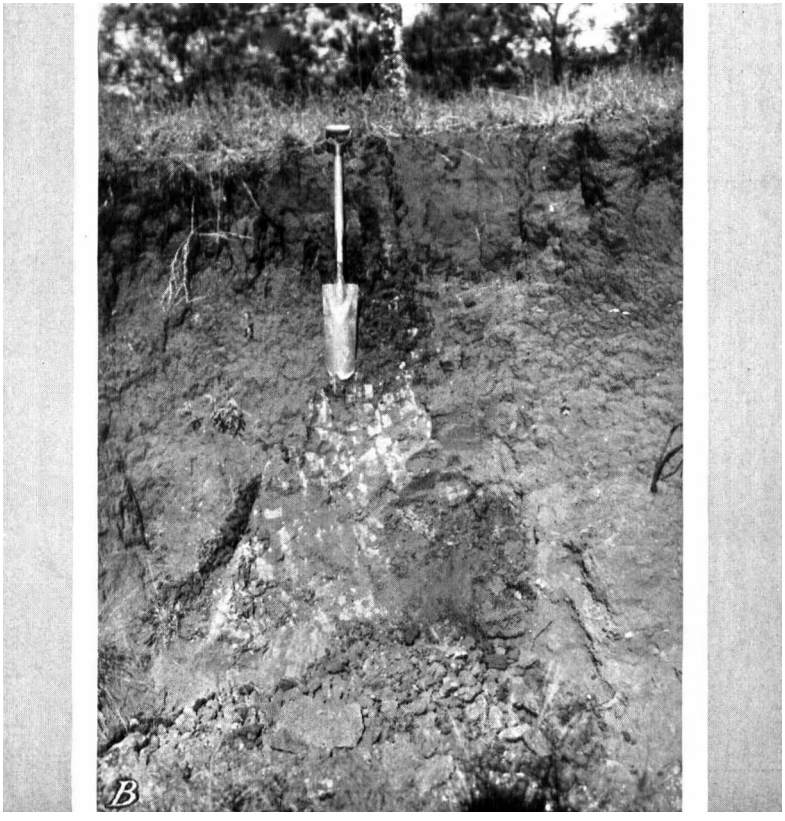
Duval fine sandy loam, shallow phase.—Small areas of Duval fine sandy loam, in which erosion has been severe, are separated as a shallow phase. Much of the surface soil has been washed away, and the subsoil layers also are rather thin and poorly developed in many places. The surface soil is reddish-brown fine sandy loam and ranges from only 2 to 6 inches in thickness. It grades into red fine sandy clay, which, below a depth of 10 to 14 inches, rests on calcareous gray and yellow compact sandy clay, the undeveloped parent material. Ironstone fragments are abundant in places.

This shallow soil occupies steep or moderate slopes in the southeastern part of the county, associated with the typical soil. The surface is more steeply sloping and rolling than that of the typical soil, and the native vegetation is much thinner. Little grass grows on this soil, and the shrubs are small and stunted. They are of the same species, however, as those growing on the typical soil.

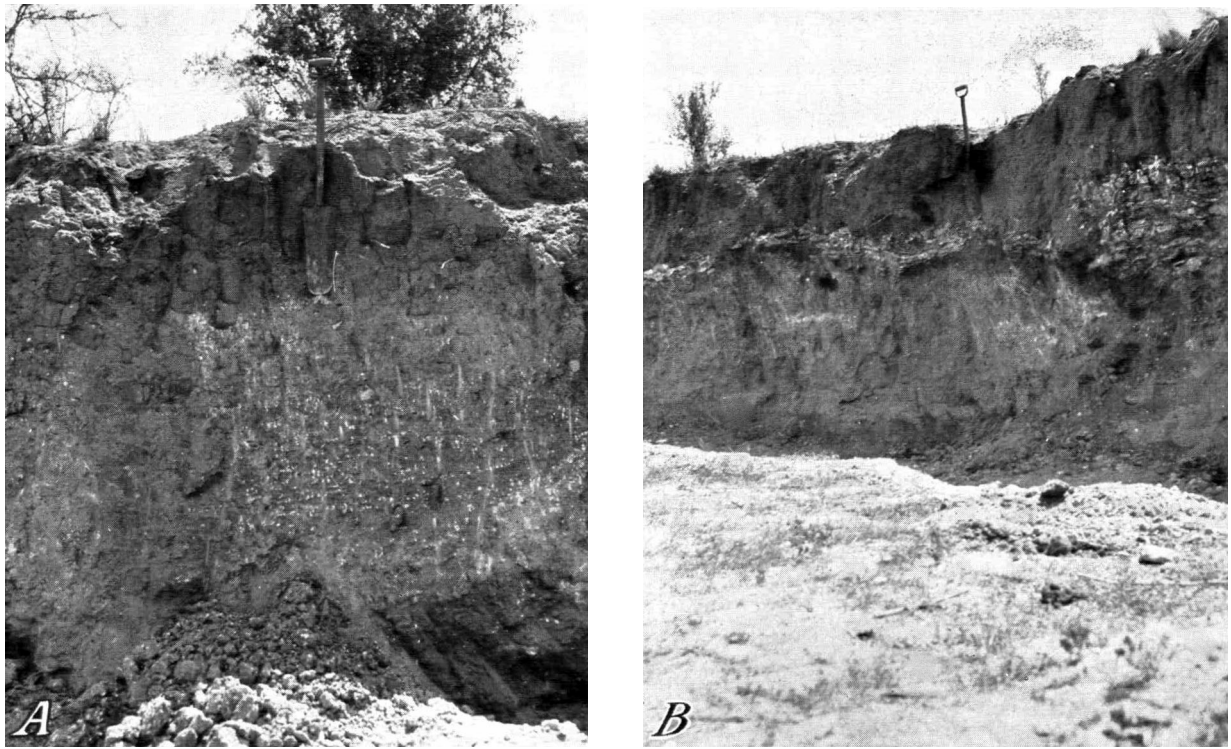
Duval fine sandy loam, shallow phase, is not highly valued for grazing, nor is it of much value for the production of farm crops. Crop yields would probably be very low even if the soil were irrigated, and certainly it is not well suited to dry farming. It is not too steep for cultivation and could be reclaimed by terracing and proper management, but a long time would be required before the most severely eroded spots would return good crop yields.

Webb fine sandy loam.—Webb fine sandy loam somewhat resembles Duval fine sandy loam, with which it is associated in the southeastern part of the county. It differs from that soil in that it is less red in color and has a denser, heavier textured subsoil. The 10-inch surface soil is dark reddish-brown fine sandy loam, which





A, Saladillo (*Varilla texana*) and alkali weed (*Sellou glutinosa*) growing on Maverick clay, saline phase; *B*, profile of Duval fine sandy loam near Loma Vista.



A, Profile of Crystal fine sandy loam near Crystal City, *B*, profile of Maverick fine sandy loam near Crystal City.

is almost abruptly underlain by the subsoil of reddish-brown or brownish-red slightly sandy heavy clay. Below a depth of about 20 inches this material grades into reddish-yellow less heavy fine sandy clay that is somewhat calcareous and contains concretions of calcium carbonate below a depth of 30 inches. The sandstone or calcareous sandy clay parent material lies from 4 to 6 feet beneath the surface.

The surface soil and upper layers of Webb fine sandy loam are neutral or slightly acid. The organic-matter content is low, and it is reported that in places the thoroughly dried soil tends to form a hard surface crust.

Within areas mapped as Webb fine sandy loam are small spots where a larger proportion of the surface soil has been removed by erosion and the lower horizons are generally thinner than in the typical soil. Grass is sparse in these included areas, and they have little value for grazing or for any other agricultural purpose. In other places small included areas have a dark surface soil of fine sandy clay loam underlain at a depth of about 12 inches by red or reddish-brown clay, which is calcareous in places. Such areas represent spots of San Antonio sandy clay loam that are too small to show on a small-scale map.

This soil is extensive and occurs in fair-sized areas throughout the western and southeastern parts of the county. The surface, in general, is flat or gently undulating, and some areas are slightly depressed. Surface drainage is fairly free, but underdrainage is very slow.

The grass cover is fairly abundant but not thick. It includes chiefly coarse grasses, although some species of grama, *Aristida*, and three-awn grasses grow. Small mesquite trees and thorny shrubs, including soapbush, catclaw, yucca, blackbrush, guajillo, whitebrush, and pricklypear, also grow moderately thick.

Webb fine sandy loam is farmed to a slight extent, both under irrigation and under dry farming, in connection with soils of the Crystal, Duval, and other series. The soil is well suited to the production of general farm crops and to many of the truck crops, and yields are approximately the same as, or slightly higher than, those obtained on Crystal fine sandy loam.

Crystal fine sandy loam.—Crystal fine sandy loam is somewhat like Duval fine sandy loam in structure but is less red than that soil, resembling Webb fine sandy loam in color. It contains noticeably larger quantities of medium and coarse sand particles than do soils of those two series. The surface soil is brown or slightly reddish brown fine sandy loam, about 12 inches thick. It grades into brown or slightly reddish brown fine sandy loam or fine sandy clay loam, which, below a depth of 30 inches, passes into yellowish-brown calcareous fine sandy clay containing concretions of calcium carbonate. This material, in turn, rests on weathered sandstone at a depth ranging from 6 to 8 feet. The upper soil horizons are not calcareous but are neutral or slightly acid. The soil does not contain much organic matter. Plate 2, *A*, shows a profile of this soil near Crystal City.

The soil is not extensive in this county. Some widely separated areas are associated with Maverick fine sandy loam and Webb fine sandy loam in the western half. Bodies are northwest and south-

west of Loma Vista and near Crystal City. The relief is undulating, and drainage is good. The soil appears to have been developed from sandstone or sandy beds of the Carrizo geological formation.

The native vegetation includes small and large bunchgrasses and mesquite trees, together with the same species of shrubs as grow on the Duval and Webb soils. The soil is only moderately productive, but it is favorably situated for irrigation and is farmed, especially for the growing of winter vegetables and truck crops, chiefly spinach, onions, tomatoes, and peppers. Some feed crops are grown without irrigation. Yields are fairly good, and, when commercial fertilizers are used, the crops respond well. Under irrigation spinach yields an average of 250 bushels an acre, onions 150 bushels, and corn about 35 bushels.

Crystal fine sand.—The surface soil of Crystal fine sand is light-brown or reddish-brown loose fine sand with a neutral or very slightly acid reaction. The content of organic matter is very small and, in places, the content of fine material is sufficient to make the texture a loamy fine sand. In places the material is slightly darker than is typical to a depth of several inches; in other places the reddish-brown fine sand is essentially the same from the surface to a depth ranging from 18 inches to 5 feet. In places, below the thick layer of fine sand is mottled red, yellow, and gray rather dense clay; elsewhere the material in the lower part is fine sand, which rests, at a depth ranging from 6 to 8 feet, on sandstone or strata of sand. No calcareous material is present in the fine sand from the surface downward, but the clay beneath it may be slightly alkaline.

Crystal fine sand occurs in several large areas in the northwestern and north-central parts of the county. It represents the outcrop of Carrizo sand, the formation lying deeply beneath the surface of much of the county and the reservoir for the large quantity of underground water from which irrigation water is obtained by pumping from wells. The surface is undulating, and slopes are gentle. Much of the soil occupies slight smoothly rounded ridges. Both surface and internal drainage are excellent; in fact, in the deeper phases of the soil the material is rather porous and leaches readily.

The native vegetation consists chiefly of coarse bunchgrasses, and there is some grama grass, mostly hairy grama. A few comparatively large mesquite trees are scattered here and there, with a few small shrubs, pricklypear, and Spanish-dagger. In places small trees of *Bumelia* species grow.

Very little of Crystal fine sand is cultivated in this county, and practically all of it is used as range land within the cattle ranches. It does not have a large reserve of fertility, but it can be improved by fertilization. It is suited to the production of melons, cantaloups, and other truck crops, and probably certain fruits and berries would do well on it under irrigation. A few small plantings of citrus fruits indicate that these trees grow well.

BROWN SANDY SOILS

The group of brown sandy soils includes Brennan loamy fine sand; Brennan fine sandy loam, shallow phase; Maverick fine sandy loam; and Miguel fine sandy loam. These soils are widely scattered in small areas throughout various sections of the county, and their com-

bined area represents only 3.9 percent of the total area. Common features are the rather smooth lay of the land, the comparatively light colored surface soils, and fairly heavy textured subsoils. These soils are moderately fertile but are not used extensively for cultivated crops, probably because other soils that are inherently more fertile and more favorably situated for irrigation are still available. Excepting Maverick fine sandy loam, which is strongly alkaline throughout, these soils have neutral or very slightly acid surface soils, and the lower horizons are more or less calcareous. The parent materials are siliceous—largely sandy clays or calcareous sandstone materials, which have not weathered deeply in places, so that the resulting soils are shallow and the layers are thin. These soils are considered less valuable for cultivated crops than are the typical reddish-brown sandy soils.

Brennan loamy fine sand.—The 15-inch surface soil of Brennan loamy fine sand is brown or grayish-brown loamy fine sand. This grades into yellowish-brown loamy fine sand or fine sandy loam, and this, at a depth of about 24 inches, passes into brownish-yellow fine sandy clay loam or fine sandy loam, which continues to a depth of several feet. Above a depth of 3 feet neither the surface soil nor the subsoil is calcareous, but below that depth some calcium carbonate concretions are present. In places, the heavier lower subsoil layer of brownish-yellow fine sandy loam or fine sandy clay loam lies within 15 inches of the surface.

This soil is of slight extent but occurs in numerous small areas in the eastern part of the county. The surface is almost flat or very gently undulating, and drainage is good. The soil has developed from sandstone or sandy beds. It borders shallow valleys.

There is a native growth of coarse grasses, mesquite trees, and many shrubs, such as huisache, lotebush, false-mesquite, pricklypear, and others.

Brennan loamy fine sand is included in ranches, where it is used entirely for grazing livestock. If irrigated, the soil probably would produce fairly good crops of some general farm crops and vegetable and truck crops. It is only moderately fertile but, if irrigated, is likely to respond well to the application of manures and commercial fertilizers.

Brennan fine sandy loam, shallow phase.—The surface soil of Brennan fine sandy loam, shallow phase, is brown or grayish-brown fine sandy loam about 12 inches thick. It grades into lighter brown fine sandy clay loam, which is calcareous in places. At a depth ranging from about 20 to 30 inches, this rests on white chalky caliche, or calcium carbonate, which, in places, is rather hard and stonelike.

This soil is developed in several large areas in the eastern part of the county near the Leona River Valley southeast of Batesville. These areas, which are smooth and benchlike, have some appearance of old stream terraces. Possibly the soil has developed from very old water-laid material. Natural drainage is very good.

Large mesquite trees and many kinds of shrubs, including large catclaw, sumac, whitebrush, guayacan, and black persimmon, locally called Mexican persimmon, are abundant on the virgin soil. Occasional clumps of live oak trees are surrounded by the more semiarid types of plants.

None of the soil is in cultivation, and it is used only as range. The soil probably would not be highly productive for farm and truck crops, but areas in which the soil material is thicker might produce very good yields of some crops under irrigation.

Maverick fine sandy loam.—Maverick fine sandy loam is one of the widely distributed brown sandy soils of the extreme western part of the Rio Grande plain. The surface soil is grayish-brown fine sandy loam, which is calcareous in most places. It is about 10 inches thick and grades into light grayish-brown or yellowish-brown crumbly calcareous clay or fine sandy clay, which, at a depth of 26 to 30 inches, passes into highly calcareous light-gray or yellowish-gray fine sandy clay containing soft and hard concretions and lumps of calcium carbonate. This layer is several feet thick and rests on disintegrated calcareous sandstone. In some small flat areas the subsoil is a very heavy clay, although the material is calcareous. A profile of this soil is shown in plate 2, *B*.

Maverick fine sandy loam occurs chiefly in small areas in the southwestern part of the county. The relief ranges from undulating to rolling, and drainage is free.

A moderate growth of short grasses, many low brushy shrubs, and a scattered growth of mesquite trees constitute the native vegetation.

This soil is included largely in ranches and is used for the grazing of range livestock. Some of it is cultivated in fields with other soils, especially with Crystal fine sandy loam and Webb fine sandy loam. It is said that about the same crops are grown, with approximately the same results, as on Crystal fine sandy loam. This soil is reported to be well suited to the production of early onions.

Miguel fine sandy loam.—The surface soil of Miguel fine sandy loam is brown or slightly reddish brown fine sandy loam, which, when dry, is rather hard and compact. It is not calcareous, but it is only slightly acid or neutral. It is underlain, at a depth of about 12 inches, by brown or reddish-brown tough clay of claypan character. Below a depth of about 24 inches, this material grades into reddish-brown or yellowish-brown heavy clay containing fine concretions of calcium carbonate.

Small areas of this soil are in the southeastern part of the county northwest and south of Loma Vista. These areas are flat and in places are slightly lower than the surrounding land. Both surface and internal drainage are slow.

The virgin soil is covered with a thick growth of bunchgrasses, together with some grama and other grasses, mesquite trees, and various shrubs, including whitebrush, soapbush, false-mesquite, and prickly-pear. This soil probably is well suited to growing general farm crops when moisture conditions are favorable. At present, however, its principal use is for grazing livestock on large ranches.

SOILS AND LAND TYPES UNSUITED FOR CULTIVATION

Several soils and land types are almost entirely unsuited for the production of farm crops. These soils differ widely in their characteristics, and their only common feature is their unsuitability for cultivation. Rapid surface erosion and lack of deep moisture penetration have prevented the development of a deep soil profile in several of these soils and rendered the soils unfit for farming. Included

in this group are Maverick clay loam; Maverick clay, saline phase; Maverick clay, gravelly phase; Uvalde gravelly loam; Zapata fine sandy loam; Zapata gravelly loam; Webb gravelly fine sandy loam; Randall clay; and riverwash. Combined, they cover 14.8 percent of the total area of the county.

Maverick clay loam.—Maverick clay loam is the most extensive soil of the Maverick series, but in most places it is not sufficiently productive for farm crops. The 4- to 10-inch surface soil in most places is brown or grayish-brown calcareous clay loam. Some small areas having a clay surface soil are included with this soil in mapping. Much chert gravel is scattered over the surface in places. The subsoil is mottled rusty-brown and gray calcareous clay, which contains some chalky calcium carbonate and, below a depth ranging from 3 to 4 feet, merges with gray shaly clay stained or mottled with rusty brown. This soil is formed from shaly clay, but soil development is imperfect, being confined to the very thin topmost layer.

This soil occurs on ridges and hills, chiefly in the western part of the county. It is gently to moderately sloping and undergoes considerable gullying and sheet erosion.

The thin grass cover consists mainly of red grama grass. The growth of shrubs is chiefly blackbrush, small mesquite trees, and creosotebush. The soil is used only for what grazing it affords. A few areas having smoother relief probably would produce moderate to low yields of certain crops, such as onions and forage.

Maverick clay, saline phase.—The surface soil of Maverick clay, saline phase, is grayish-brown or brownish-gray heavy waxy clay, which, in most places, is calcareous. This layer ranges from 3 to 10 inches in thickness, the average thickness being about 6 inches. On drying, the soil material separates naturally into fine rough clods. Beneath this layer is grayish-brown or brownish-gray dense waxy calcareous clay, which, on drying in exposed situations, separates into small slick-surfaced clods. Below a depth ranging from 18 to 30 inches, this material, in turn, grades into yellowish-brown or gray brittle calcareous clay containing a small quantity of calcium carbonate concretions. This material passes, at a depth ranging from 30 to 50 inches, into bluish-gray and yellow mottled shaly clay. The soil has developed from shale or shaly clay, and the substratum and the subsoil above it contain much gypsum in the form of soft fine particles as well as large quantities of sodium salts ("alkali"). The profile is shown in plate 3, *A*.

Maverick clay, saline phase, is fairly extensive, and there are many small and some large areas in the southwestern part of the county, west of the Neuces River Valley north of Crystal City, east of that valley in the central part, and southwest of Loma Vista. The relief is more sloping, drainage is freer, and erosion is more active than is characteristic of Maverick clay loam. Some areas occupy slopes leading down from smooth flat areas of Monteola clay. In places these slopes are so steep and so gullied as to form rough broken land. The dense clay absorbs water so slowly that most of the rain water runs off.

The native vegetation is scant, and areas of this soil are conspicuous by the very small number of mesquite trees and the larger species of shrubs. Some short grasses and tobosa grass grow, but the grass cover in most places is rather thin. The characteristic vegetation

is a weed, locally called saladillo, which appears to be a salt weed (pl. 1, *A*). It has been identified as *Varilla texana*. Ranchmen report that cattle having access to this plant need not be furnished with salt.

Because this soil is shallow and salty and the surface soil is eroded, it is of very low productivity. The lack of moisture-storage capacity also renders it unsuitable for the production of farm crops. It is used only for the pasturage of ranch cattle.

Maverick clay, gravelly phase.—The 8-inch surface soil of Maverick clay, gravelly phase, is dark grayish-brown calcareous clay containing a large quantity of subangular and rounded chert gravel, from ¼ to 2 inches in diameter. The surface soil grades into grayish-yellow calcareous clay. In places, the subsoil contains chalky material and little gravel, and in other places it contains a large quantity of chert gravel with some calcium carbonate material around the particles of gravel. Very little gravel is present below a depth of about 2 feet, but the material is calcareous and contains considerable quantities of fine soft gypsum crystals. The parent shale or shaly clay lies from 2 to 4 feet below the surface.

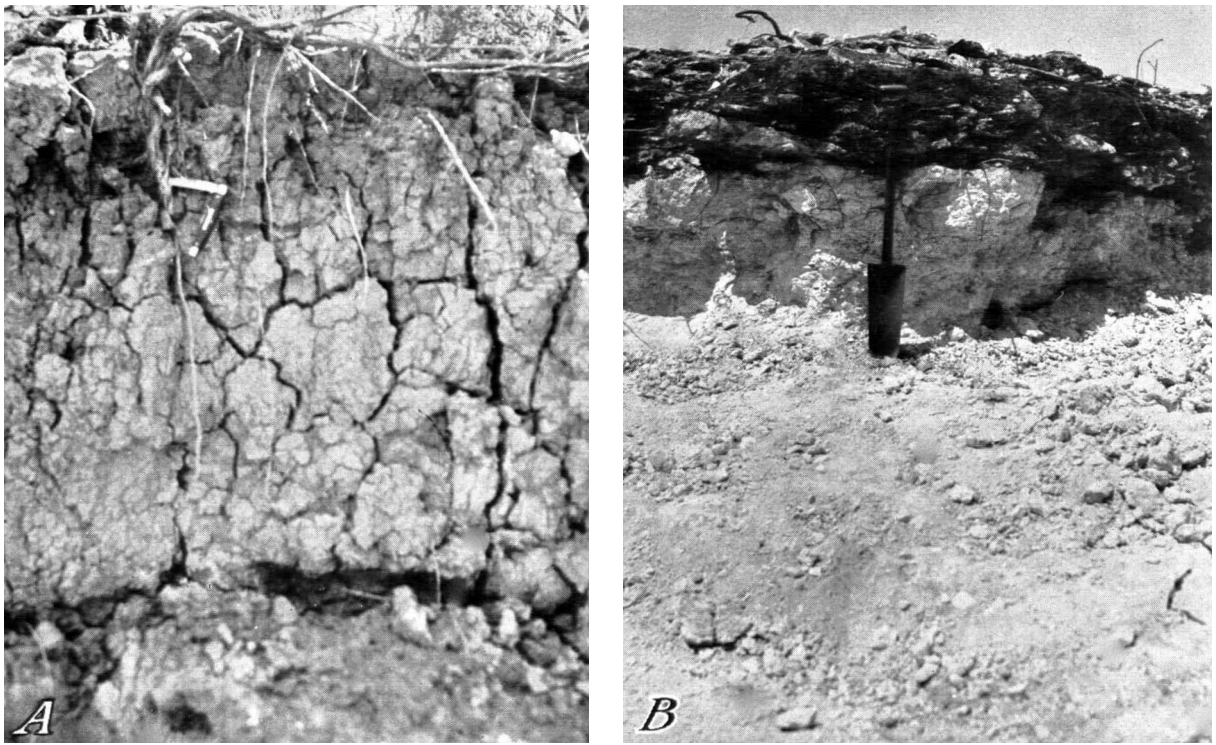
Maverick clay, gravelly phase, is not extensive. Most of the small areas are in the north-central and northeastern parts of the county. The relief is rolling, and the slopes are steep in places. The soil, therefore, erodes easily, although it is protected somewhat by the gravel.

The native vegetation is not abundant. The grass cover of grama, *Aristida*, and other species is thin. Shrubs are mostly guajillo, small mesquite, blackbrush, and other thorny shrubs. Although the grass affords scant grazing, the shrubs, especially guajillo, which is relished by cattle, sheep, and goats, afford some browse for livestock. Most of this land is in pastures on ranches.

Uvalde gravelly loam.—This soil consists of dark-brown or dark grayish-brown calcareous gravelly loam or gravelly fine sandy loam, overlying a deep bed of rounded and subangular gravel. In places the soil material consists almost entirely of gravel. The gravel is largely chert and limestone, with some sandstone and quartzite. Below a depth ranging from a few to more than 12 inches, the material grades into chalky highly calcareous light-gray or yellow loam containing much gravel, and this, in turn, continues downward to a depth of several feet. In many places the gray chalky material—caliche—cements the subsoil gravel into a hard mass. In the valleys near the Nueces River the gravelly material extends to a depth of many feet, but on some of the higher upland positions it rests on soft sandstone at a depth of only a few feet.

Small bodies of this soil, with a small total area, occur adjacent to the larger streams and on the marginal slopes of high terraces of Uvalde soils, mainly along the Nueces River Valley in the northern part of the county.

The relief ranges from gently rolling to steeply sloping, and drainage is rapid. The native vegetation, which is not heavy, consists mostly of scattered shrubs, mainly guajillo, blackbrush, and cenizo. Very little grass grows on this soil. It includes species of coarse and small bunchgrasses. The land has little value for grazing, but some of the shrubs afford valuable browse. The land has no value for cultivated crops.



A, Profile of Maverick clay, saline phase, near Crystal City; *B*, profile of Zapata fine sandy loam, near Batesville.

A, Harvesting spinach on Frio silt loam; *B*, harvesting onions on Montcola clay

Zapata fine sandy loam.—Zapata fine sandy loam is subject to erosion and has only a thin slightly developed light-colored surface soil resting on caliche. The surface soil, a grayish-brown or brownish-gray calcareous fine sandy loam, ranges from 4 to 14 inches in thickness. The white or cream-colored caliche on which it rests is many feet thick and, where not exposed at the surface, is rather soft and floury. Some fragments of caliche occur through the surface soil in places, and on some slopes the bed of hard caliche outcrops. Plate 3, *B*, shows a profile of this soil.

This soil is not very extensive. The relief is gently rolling, and some slopes are so steep as to promote erosion. The native vegetation is very scant, and little grass grows. There are some small shrubs and brushy growth consisting largely of guajillo, cenizo, and other plants.

The soil is of no value for cultivated crops and of little value for grazing or browse. It is in large pastures and is used only for range land for livestock.

Zapata gravelly loam.—The 4- to 12-inch surface soil of Zapata gravelly loam is gray or grayish-brown loam or fine sandy loam. Rounded and subangular fragments of chert and limestone are present. The soil rests on white caliche, which is soft except in places near or at the surface, where it has dried and hardened. The soil is thin and has a profile very similar to that of Zapata fine sandy loam, except for the greater content of gravel.

The small total area of this soil is used only for the grazing afforded by the thin growth of short grasses and small bunchgrasses, and for the browse afforded by the shrubs.

Webb gravelly fine sandy loam.—Webb gravelly fine sandy loam is an extensive range land in the ridges and rolling areas in the northeastern part of the county. The 10-inch surface soil is red or brownish-red fine sandy loam containing a large quantity of small rounded and subangular gravel, largely chert. It grades into very heavy red gravelly clay, which, at a depth ranging from 1 to several feet, rests on a bed of massive hard caliche of calcium carbonate, containing, in places, a large quantity of gravel. The caliche is several feet thick and overlies calcareous sandstone.

The relief ranges from undulating to rolling, and drainage is free. The native vegetation consists of a thin growth of bunchgrasses, with some grama grass, and a rather heavy growth of shrubs, such as guajillo, blackbrush, catclaw, pricklypear, and others. The soil has no value for cultivated crops but affords good browse for cattle, sheep, and goats.

Randall clay.—Randall clay comprises a few small flat depressed areas of rounded outline, which are lake beds covered with water for some time after heavy rains but remaining dry most of the time. The surface soil is very dark gray clay which becomes lighter gray with depth. In places, gypsum crystals are present in the subsoil below a depth of several feet. When thoroughly dry the soil cracks deeply.

The lake beds are very small, with a maximum size of 40 acres. Underdrainage is almost entirely lacking, and water stands on the surface until removed by evaporation. The growth of grass is scant except around the edges of the areas. Mesquite grows in places, and

Jerusalem-thorn is abundant. As the soil is very heavy and intractable, it is not suited for growing farm crops.

Riverwash.—Riverwash comprises low-lying areas of loose sand and gravel along the stream channels above the normal stage of water. These deposits of loose material are shifted about by floodwaters and have no definite soil arrangement. The vegetation is very sparse. This land occurs chiefly in small areas along the Nueces River in the northern part of the county. It has no value for farming.

LAND USES AND AGRICULTURAL METHODS

The production of beef cattle on native grasses is the leading agricultural enterprise in the county. Most of the land is used for range livestock, chiefly cattle, but also sheep and goats. Steers are shipped direct to market or for fattening in the north. In general, the grass and brush cover furnishes sufficient feed. Owing to the small amount of moisture, the cover is not heavy, but the grasses, leaves, and beans of the brush are highly nutritious. Some of the best grasses are curly mesquite, buffalo, and several gramas. Tobosa grass, which has a scattered growth over the county, is edible and nutritious when it is young and tender. Mesquite, guajillo, whitebrush, catclaw, huisache, blackbrush, and other plants furnish valuable browse. During long recurrent dry periods when there is a shortage of grass, pricklypear is an excellent reserve feed, which is made available by burning off the spines with a gasoline torch.

Water is obtained on ranches from shallow wells or from small lakes made by excavating and damming the small creeks and drains. In some places, however, the wells produce only salty water.

Auxiliary feeding of grain or cottonseed cake to cattle is resorted to only during periods when the native grass is exhausted, and then only until rain renews the pastures. It is estimated by ranchmen that under normal conditions from 15 to 20 acres of range land is required to support one steer.

Most of the beef catttle are improved grades of Hereford breeding. Goats have long been raised in the county. In recent years the Angora breed has been introduced, and mohair is an important product. Sheep, formerly raised in large numbers, are of less importance than formerly, but some are still raised on ranches and kept for the production of wool. They are mainly grade animals of the Merino and Rambouillet breeds, which are the fine-wool types.

Dry and irrigated farming are the two systems used in crop production. Cotton, corn, sorgo hay, Sudan grass hay, and grain sorghums are the chief crops grown under the dry-farming system. The soils used for dry farming are mainly Duval fine sandy loam, Webb fine sandy loam, Crystal fine sandy loam, Maverick fine sandy loam, and Uvalde silty clay loam. Crops on the fine sandy loams resist drought better than on Uvalde silty clay loam, but the latter is the most fertile soil and produces higher yields when moisture is adequate.

The success of the irrigation enterprises may be attributed to the adequate supply of pure water, the mild climate, and suitable soils that occur in broad smooth areas. Because of the irrigation water, which may be procured from the wells, rivers, and bayous, irrigation

farming is concentrated in the Nueces River Valley and the adjacent uplands.

The heaviest yields of vegetables are obtained on the dark-colored soils, because of their high content of organic matter and inherent fertility. The most desirable soil for the production of spinach probably is Frio silt loam (pl. 4, *A*), as its open physical structure allows excellent underdrainage. The red sandy soils produce good yields of spinach, but the sand is not easily washed off the leaves. Local growers report that yields decrease rapidly after the third or fourth year of continuous cropping to spinach, and it has been noted that the sandy upland soils are more responsive and are easier to rehabilitate than are the dark-colored soils.

Webb fine sandy loam, Crystal fine sandy loam, and Maverick fine sandy loam are probably the best soils for the production of onions. Monteola clay (pl. 4, *B*), Monteola clay loam, and Uvalde silty clay loam are said to produce the best crops of late onions. The sandy soils must be fertilized in order to return maximum yields, but high yields are obtained on the heavy soils without the use of fertilizers. It is reported that onions are not grown so successfully on the Frio soils of the first bottoms as on the Uvalde soils of the old terrace benches.

Corn returns as high as 60 bushels an acre on the alluvial soils, but the average yield is 35 or 40 bushels.

A well-defined and routine system of cropping and agriculture has not been perfected in this county, and the merits of many crops have yet to be proved or established.

In the irrigated areas spinach is the chief crop. Both savoy and flat-leaved types are grown. The seed is sown broadcast from time to time between the latter part of September and the first of February. Parallel borders are thrown up at intervals ranging from 12 to 15 feet in the direction of the fall of the land. These are crossed at right angles at intervals ranging from 150 to 200 feet by lateral canals, which are given enough fall to deliver the water freely without washing the soil. The arrangement of borders may vary to suit the conditions of slope and types of soil. Water is let into the borders from the canal on the upper side, and baffles of earth on either side of and at right angles to these borders help to spread the water evenly over the seedbed. From one to four irrigations are required to mature a crop during the growing season, which is from 75 to 90 days.

Fertilizers are not used, and the yields are reduced after a few years of continuous cropping to spinach. One or two crops a year are grown on the soil, and the land is kept fallow the rest of the time. This is not regarded by some farmers as a good practice, because it tends to facilitate the oxidation and destruction of organic matter, which is normally deficient in the soils of this section, and to encourage the growth of weeds. Broadcast sowing of seed prevents cultivation and also favors the growth of weeds. Downy mildew on jointweed is the most outstanding disease likely to attack the spinach plants. Cultivation of spinach in rows and crop rotation might lessen the damage done by diseases.

The seeding period is spread out, in order to avoid the possible necessity for disposing of the entire crop on a low market, but the price fluctuates throughout the season, as no cooperation among growers exists for control of the rate of marketing.

Dry onions are the second important irrigated winter vegetable. The most popular variety is the Yellow Bermuda, the seed for which is imported largely from the Canary Islands. The crop is sown in seedbeds during the latter part of September, and the plants are transplanted in rows in the field late in November. The crop is harvested from March to June. All work is done by hand. Other vegetables grown under irrigation to some extent are tomatoes, peppers, and broccoli. Many others are also grown in a small way.

Fertilizers applied to light-textured sandy soils increase yields of onions. Varying quantities and mixtures are used, although the usual application is from 400 to 600 pounds of 6–12–6 [8] to the acre. The Texas Agricultural Experiment substation No. 19 at Winter Haven has been carrying on experiments to determine the rate and frequency of application and the kind of fertilizer best suited to onion culture.

Pink root and onion thrips may be controlled partly by rotation of crops, use of fertilizer, and cultural practices that encourage continuous, rapid, and steady growth.

A few small acreages of feedstuffs, such as corn, Sumac or Red Top sorgo, and Sudan grass, are planted on some of the irrigated farms to furnish feed for livestock. Yields under irrigation are considerably higher than under dry farming.

Dry farming is practiced to a limited extent, mainly in connection with livestock farming and ranching. The system of dry farming is more or less intermittent, as the fields may lie idle during the years when the feed supply is abundant or the moisture content of the soil is not sufficient for crop production. No effort is made to improve the soil by crop rotation or by use of fertilizers. The land is prepared in the fall, and, if the precipitation warrants, the seed is planted in early spring. Corn is planted in late January or early February, and it matures in June or July. The chief varieties are Surcropper and Mexican June. Cotton is planted in March, as later plantings are more subject to boll weevil infestation. Mebane and Harper are the principal varieties. Hegari and milo are the chief varieties of grain sorghums. Sorghums are often cut green for forage to feed the farm animals.

In recognition of the many problems of this newly developing section and in response to local demand, substation No. 19 of the Texas Agricultural Experiment Station was established in 1929 at Winter Haven in Dimmit County, 5½ miles southwest of Crystal City. The farm includes about 192 acres, of which approximately 100 acres are in cultivation. Most of the land has been terraced to prevent erosion. Experimental work is continuous throughout the year, and emphasis is placed on the production of fruit and vegetables under irrigation. The purpose of this work is to aid in the development of the agricultural resources of the area by finding more efficient methods and systems of crop production and to introduce additional crops that are profitable supplements to spinach and onions. In most instances the experiments have not been conducted long enough for definite interpretation of results. Variety tests have been carried on with vegetables, fruits, field crops, and ornamental plants. Tests involving the kind, rate, and frequency of fertilizer

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

applications indicate that yields of onions increase with every increase of nitrogen or phosphoric acid in the formulas. Irrigation experiments have shown that probably a minimum amount of irrigation and greater frequency of application during the bulbing period would increase yields of onions.

IRRIGATION

The first irrigation in Zavala County was concurrent with the first farming done near Batesville in 1876, when several hundred acres were irrigated from a reservoir on the Leona River. Although artesian water was discovered near the county as early as 1885, no attempt was made to use this for irrigation until about 1907, when ranch lands in the southern part were subdivided and sold to settlers. Artesian wells were bored and irrigation from wells began soon after settlement along the railroad, which reached Crystal City in 1908. The first irrigation from wells was near Crystal City and Cometa, and at about the same time water for irrigation was obtained from the Nueces River. All water from streams had to be pumped, and most of the artesian wells became reduced in flow, so that water soon had to be pumped from these also. The wells range from 300 to 1,800 feet in depth, and water rises to a level ranging from 40 to 300 feet below the surface. The water is lifted by pumps that can draw up to several hundred gallons a minute. Pumps also lift water from 20 to 60 feet from the rivers and lakes.

Farms irrigated from wells range up to several thousand acres in size, although it is considered that one well will supply sufficient water to irrigate 150 acres or a little more.

The principal crops grown under irrigation are spinach and onions, with small amounts of tomatoes, peppers, and many other vegetables. Crops were harvested on 86 farms from 19,616 acres of irrigated land in 1934 in this county.

The water from wells in the Carrizo sand formation is plentiful at present and of good quality for irrigation. Investigations, however, indicate that the supply is not unlimited.

Many of the soils are well suited to irrigation. Some have good underdrainage, but others are so heavy that an excess of irrigation water may cause waterlogging and an accumulation of soluble salts. It should be borne in mind, however, that it is essential to apply sufficient water to obtain thorough deep penetration, otherwise salts will accumulate in the surface soil and subsoil. Much of the water from wells and from streams is comparatively free of salts injurious to plant growth, but injudicious use of water, especially on soils that are heavy and slowly drained, might cause an accumulation of salts in the surface or subsoil layers. Salts may be observed as an almost white powdery material on the dried surface, or their presence may be indicated by a characteristic vegetation, such as the saladillo plant on Maverick clay, saline phase (pl. 1, *A*). A sample of the surface soil when analyzed showed a total of 0.1213 percent of salts, including carbonate of lime, 0.0262 percent; sulfate of lime, 0.0022 percent; sulfate of magnesia, 0.0094 percent; sulfate of soda, 0.0073 percent; and chloride of soda, 0.0762 percent. Chloride of soda, the most injurious of the principal soluble salts in the soil, is highly soluble and in many places an injurious factor in this section. It is locally

called "alkali" but is not true alkali (carbonate of soda), which is a much more injurious salt occurring in some sections of the West.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of the environment acting upon the soil materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent soil material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the relief, or lay of the land, which determines the local or internal climate of the soil, its drainage, moisture content, aeration, and susceptibility to erosion; (4) the biologic forces acting upon the soil material, that is, the plants and animals living upon and in it; and (5) the length of time climatic and biologic forces have acted upon the soil material.

In southwestern Texas the soils of the great group designated as the Reddish Chestnut soils grade into those called the Reddish Brown soils.[9] Zavala County lies on the approximate boundary between the two soil regions. It is a warm-temperate semiarid country having an annual rainfall of about 20 inches. Because the rainfall is comparatively low, the soils are not strongly leached but have a rather high content of bases, and most of them have a definite layer of accumulated carbonate of lime in the subsoil. The absence or imperfect development of this layer indicates lack of normal mature soil development. It occurs nearer the surface in the normally developed soils of this area than in soils farther east, where the rainfall is greater. As a result of the vegetation of short grasses and bunchgrasses a considerable accumulation of organic matter is present in the surface soils, imparting a fairly dark color, although the quantity of this constituent generally is less and the color of the soils is lighter than in the country farther east, where the grass growth is more abundant.

There are two large groups of soils in the county: (1) Soils with reddish-brown or dark reddish-brown surface soils over red subsoils, grading with depth into grayer calcareous material; and (2) soils with dark-gray or dark brownish-gray heavy calcareous surface soils over light-gray or almost white limy subsoils.

The soils are normally mildly alkaline in reaction. Table 4 gives pH values of samples of two soils. The determinations were made by the hydrogen electrode method in the laboratories of the Bureau of Chemistry and Soils.

TABLE 4.—*pH determinations of samples of two soils in Zavala County, Tex.*

Soil type and sample No.	Depth	pH	Soil type and sample No.	Depth	pH
Monteola clay:	*Inches*		Crystal fine sandy loam:	*Inches*	
449008	0 – ¼	7.8	449018	0 – 1½	8.0
449009	¼– 8	8.3	449019	1½– 36	7.8
449010	8 –30	7.7	449020	36 –120	7.8
449011	30 –84+	7.6	449021	120+	8.2

[9] UNITED STATES BUREAU OF CHEMISTRY AND SOILS. SOILS OF THE UNITED STATES. U. S. Dept. Agr. Yearbook 1938 (Soils and Men): 1085, 1092–1093, illus. 1938.

The parent materials from which the soils have developed consist of weathered sandstones, sandy clays, calcareous clays, and shaly clays. These are from several formations, ranging in geological age from Quaternary to Eocene, which underlie the western extension of the Gulf Coastal Plain province. The shaly clays appear to contain considerable finely divided or platy crystalline gypsum and some calcium carbonate, and the sandy beds in places, as well as some of the sandstone, also appear to contain some calcium carbonate. The sandy clays and sandstones give rise to the redder soils, whereas the calcareous clays and shaly clays give rise to the darker or grayer soils.

The relief is comparatively smooth or gently undulating, with only small areas of strongly rolling land or steep slopes. The normally developed soils occupy smooth land having free drainage, which is not so rapid as to allow much erosion. The geological formations have weathered deeply, except on some sloping areas, where the parent materials are limited to a thin layer by constant sheet erosion. Much of the surface of the county is sufficiently smooth to make deep soil development possible.

The soils have developed under a vegetative cover of grasses, which varies in density in accordance with the relative moisture content of the different soils. These grasses are largely short grasses, such as curly mesquite, buffalo, and grama on the finer textured soils and more of the coarser bunchgrasses on the sandy soils. The encroachment of small trees and shrubs as yet has not materially influenced soil development.

Some difference of opinion exists as to whether the reddish-brown soils or the dark-gray ones represent the typical regional development. The former are somewhat less extensive in this county and this section of Texas generally, but apparently they represent the commonest development in regions with similar climate. Similar soils, developed from a wide variety of parent materials, are dominant in parts of New Mexico, Arizona, and California. They have distinct maturely developed profiles with several well-differentiated horizons, and the upper part of the solum is leached of calcium carbonate. The dark-colored soils occupy huge areas in Texas and smaller areas in the other Southwestern States and are, of course, perfectly normal soils, but they bear the unmistakable imprint of a particular type of parent material (calcareous clay), and this influence is carried through several climatic zones. This material resists leaching, and the soils developed from it have an entirely different type of profile, characterized by accumulation of organic matter in the surface soil and partial leaching of lime and other bases from the surface soil and its accumulation in the subsoil. There is no development of a red ferruginous heavy B horizon, which characterizes the redder soils. Soils from this heavy calcareous material in different climatic zones, from humid to semiarid, exhibit striking similarities. A comparison of samples of the Houston, Victoria, Monteola, and Uvalde soils shows only minor profile differences, largely differences in degree of darkness of the surface soil, accompanying differences in content of organic matter. This would lead to the conclusion that these soils are at least to some extent intrazonal, whereas the Red-

dish Chestnut and Reddish Brown soils are more definitely zonal in character.

The Reddish Brown or Reddish Chestnut soils have developed from beds of more or less sandy materials, some of sandstone but mostly of unconsolidated material, which is slightly calcareous in places. These soils have developed on smooth surfaces beneath coarse grasses and are included in the Duval, Webb, and Crystal series. The soil materials are more permeable than those of the heavy calcareous Uvalde, Monteola, and Maverick soils, and the soil water has carried the finer soil particles and colloids down and created an illuviated horizon somewhat heavier and redder than the surface soil. Calcium carbonate is leached from the upper horizons and deposited in the zone of accumulation.

Duval fine sandy loam, a representative soil of this group, has a profile which shows the following horizons:

1. 0 to 15 inches, reddish-brown or dark reddish-brown fine sandy loam, which is friable or loose and is slightly darker in the upper 2 or 3 inches of the surface soil. The material is not calcareous.
2. 15 to 30 inches, red or dark-red friable and permeable fine sandy clay. The exposed material, on drying, separates into irregular hard clods. It is not calcareous.
3. 30 to 40 inches, reddish-yellow or yellowish-red fine sandy clay, less heavy than the material in the layer above. This is a gradational horizon overlying the horizon of lime carbonate accumulation. The material is not calcareous.
4. 40 to 80 inches, the horizon of lime accumulation, a reddish-yellow calcareous fine sandy clay containing both soft and hard lumps of calcium carbonate.
5. 80 inches+, mottled yellow and gray sandy clay, which is not calcareous but in places contains thin strata of hard fossiliferous calcareous sandstone.

The Webb soils are formed from parent materials similar to those of the Duval soils, with which they are associated. The color is less red, the content of sand is smaller, and the subsoils are denser and heavier than in the Duval soils.

Similar to the Duval and Webb soils, and associated with the latter, are soils of the Crystal series. They have reddish-brown surface soils and subsoils, and the horizon of calcium carbonate accumulation lies nearer the surface than it does in the Duval and Webb soils. The Crystal soils resemble the Duval soils in structure and consistence, but they are more like the Webb soils in color. The Crystal soils are more representative of normal soils of the Reddish Brown soils region.

Miscellaneous soils of the uplands, which are less extensive and less representative of soil development as related to the regional environment, are grayish-brown or reddish-brown soils of the Brennan, Miguel, and Zapata series.

The soils of large areas in this section are developed from calcareous clay parent materials. They are chiefly of the Uvalde and Maverick series. They have crumbly, more or less granular, rather dark gray or grayish-brown surface soils over light-gray or yellowish-gray heavy but fairly permeable subsoils. Free calcium carbonate is present throughout the surface soil and subsoil and is extremely concentrated in the subsoil. The surface soils have not been strongly leached, and lime is constantly brought up by the vegetation, particularly the grasses. These soils possibly may be considered as

Rendzinas of the semiarid region rather than as the typical mature, or normally developed, soils of the region. It is probable that the very high lime content and slightly pervious character of the parent material has prevented a so-called normal development.

The profile of the soils developed on such highly calcareous heavy materials in this section is well represented by that of Uvalde silty clay loam. The profile of this soil in a representative spot 3 miles north of La Pryor is as follows:

1. 0 to 12 inches, dark brownish-gray calcareous silty clay loam. On drying the immediate surface soil is dark gray, and the soil material is smooth and soft and readily crumbles into fine particles.
2. 12 to 24 inches, brownish-gray or yellowish-gray calcareous and crumbly silty clay.
3. 24 to 60 inches, light brownish-gray soft crumbly calcareous silty clay.
4. 60 to 96 inches, light yellowish-gray calcareous silty clay containing white concretions and soft lumps of calcium carbonate. This is the horizon of calcium carbonate accumulation.
5. 96 to 130 inches, light yellowish-gray soft calcareous clay containing less of the segregated calcium carbonate than the layer above. This is the parent material.
6. 130 to 192 inches+, light-yellow or yellowish-gray gritty calcareous silty clay with no concretions or other segregated calcium carbonate. This material continues downward and in many places rests on beds of rounded gravel, which lie many feet beneath the surface.

The soil with this profile is developed on a nearly flat surface, which is a very high old stream terrace on an outwash plain lying from 30 to 50 feet above the present-day flood plain of the Nueces River. The parent material is calcareous silty clay, originally transported from limestone materials or soils of the Edwards Plateau about 20 miles north of the county. In this location the horizon of calcium carbonate accumulation is deeper and less distinct than elsewhere in this soil or in other soils, owing perhaps to the moderately free permeability of the lower horizons. In most places the horizon of accumulation lies within 3 feet of the surface and ranges from 2 to 3 feet in thickness. It consists of a mass of chalky material and hard and soft lumps and concretions embedded in yellow or gray fine earth.

The profile of Uvalde silty clay is similar to that of Uvalde silty clay loam, but the surface soil is somewhat darker and all the horizons are heavier and less permeable than in that soil, although the material is crumbly and separates into small particles.

Eroded slopes of the Uvalde soils are indicated on the soil map as a shallow phase of Uvalde silty clay loam. Here the surface soil is shallow, the subsoil is thin and not well differentiated, and the horizon of lime accumulation lies near the surface.

Maverick clay loam has a profile that indicates the effect of the regional environment on soil development from dense calcareous shaly clay, which in places contains considerable gypsum and is interbedded in places with sandstone. The profile of Maverick clay loam is as follows:

1. 2 to 6 inches, rather dark grayish-brown calcareous clay loam. The uppermost half-inch forms a crusted layer, slick on top but coarse grained on the bottom. The material beneath this crumbles to fine clods on drying.
2. 6 to 12 inches, yellowish-gray crumbly calcareous clay, which, when exposed to the air, separates naturally into fine irregular clods and rough granules that are lightly bound together. The material breaks apart readily.

3. 12 to 18 inches, mottled light-gray and yellow crumbly calcareous clay, which, when dry, is rather brittle and separates into sharp angular particles.
4. 18 to 42 inches, mottled yellow and gray crumbly calcareous clay, throughout which calcium carbonate is disseminated in soft lumps. This is the horizon of calcium carbonate accumulation.
5. 42 to 60 inches, yellowish-brown calcareous laminated joint clay, with gray shaly clay layers.
6. 60 inches +, interbedded shaly clay and soft sandstone.

The surface is gently sloping, but, owing to the slow permeability of the soil and parent material, water runs off rapidly and erosion keeps the surface soil and subsoil thin.

The results of mechanical analyses of samples of Maverick clay loam are given in table 5.

TABLE 5.—*Mechanical analyses of Maverick clay loam in Zavala County, Tex.*

Sample No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
449045	Surface soil, 0 to 12 inches	6.5	4.2	4.2	19.5	15.8	14.5	35.3
449046	Subsurface soil, 12 to 24 inches	1.2	2.2	2.7	10.3	9.9	16.1	57.6

On the same parent material as that beneath the Maverick soils but in smoother, more slowly drained areas, the Monteola soils have developed. Owing to the retention of rain water, there is a very heavy growth of short grasses, supplying a large quantity of organic matter, and these soils are very dark or black, as are the soils in the subhumid region to the east.

Following is a description of a profile of Monteola clay:

1. 0 to 10 inches, dark-gray or nearly black calcareous clay, which, on drying, separates into coarse grains and fine clods.
2. 10 to 20 inches, dark-gray calcareous clay, which, where exposed, dries and separates to small irregularly shaped rough clods.
3. 20 to 28 inches, gray calcareous clay containing a few yellow spots and some fine particles of calcium carbonate. This is a transitional layer between the horizon above and the horizon of calcium carbonate accumulation below.
4. 28 to 50 inches, mottled gray and yellow calcareous crumbly clay containing concretions of calcium carbonate. This is the horizon of accumulated calcium carbonate.
5. 50 inches +, yellow calcareous clay containing white and bluish-gray lumps of noncalcareous dense clay. Fine crystals of gypsum are in this parent material.

The surface of the virgin soil is pitted with hog wallows in many places. The 10- to 15-inch surface soil in these small depressions is very black and is not freely calcareous. The adjacent elevations are covered with a somewhat lighter colored calcareous soil. These hog wallows are caused by the cracking of the soil in very dry weather and filling of the cracks with fine surface soil by rain water.

The large number of alluvial soils that occupy a considerable proportion of the county require no detailed description in this discussion, as they have no well-developed soil characteristics but are simply deposits of soil materials located in areas in conformity with the varied depositional influences of overflow waters. These soils are of several series. Those of the Frio, Guadalupe, and Leona

series comprise soil materials washed from the limestone areas of the Edwards Plateau. The Zavala soils comprise soil materials washed from the noncalcareous sandy soils of local areas.

SUMMARY

Zavala County is in southwestern Texas in the northwestern part of the Rio Grande Plain, a westerly extension of the Gulf Coastal Plain. The surface is dissected by many large creeks and valleys of the Nueces, Leona, and Frio Rivers. Its total area is 1,290 square miles.

The county was created in 1858, but for many years it was free range country, and no permanent settlements were made until 1872. After the building of the railroad in 1908, settlement was rapid, and Crystal City became the county seat in 1928.

The short grasses, such as curly mesquite and grama, with some buffalo and other grasses, constitute the moderately dense native grass cover. Small trees and shrubs characteristic of the subhumid region cover the upland more or less thickly, and a rather heavy growth of trees lines the stream bottoms.

The climate is characterized by long warm summers and short mild winters. The rainfall is generally insufficient for successful dry farming, but, where moisture is sufficient, other climatic factors favor a widely diversified type of agriculture.

A railroad, a paved highway, and many graveled or graded roads provide adequate transportation facilities.

The greater part of the land is devoted to the raising of beef cattle on the grass and brush cover. The long grazing period and plentiful supply of nutritious grasses encourage cattle production. Hereford grade animals predominate among the cattle. Goats and sheep also are raised.

Dry farming is carried on to a slight extent, some of it in connection with ranching. Corn, cotton, and feedstuffs are grown. In some years moisture is inadequate for good crop yields because of the small amount of rainfall.

The production of winter vegetables under irrigation ranks next to cattle raising in land use. Little effort is made to improve the soils by the use of fertilizers or by rotation of crops. Spinach and onions are the chief truck crops produced, but other vegetables are grown to a small extent.

The soils of this county have developed under a semiarid climate and a grass-shrub vegetative environment, from parent materials of unconsolidated clays, sandy beds, soft sandstone, and shales.

The reddish-brown sandy soils may be considered the normally developed soils of the county. They are extensive and have developed from the sandstone and sandy clay beds. The surface soils and upper subsoil layers are not calcareous, but there is commonly a distinct accumulation of calcium carbonate in the lower subsoil layers. The siliceous parent materials are low in calcium carbonate. This group comprises the Duval, Webb, and Crystal soils.

Dark-colored heavy-textured soils have developed from calcareous clays or shales on smooth or nearly flat uplands. The surface soils are medium or dark gray to nearly black, and the subsoils are light gray or yellowish gray to nearly white and very highly calcareous.

They are commonly crumbly and permeable, although some are very heavy and slowly permeable. These soils may be considered dry-climate Rendzinas, although they are doubtless the normal development from heavy, highly calcareous parent materials. The horizon of calcium carbonate accumulation is nearer the surface than in similar soils farther east under greater rainfall. This group of soils includes the heavy soils of the Uvalde and Monteola series.

There are a number of lighter brown sandy soils of the Maverick, Brennan, and Miguel series, which seem to be more or less intermediate between the soils of the two groups described above.

The soils of alluvial materials are deep well-drained deposits transported from nearby and distant areas of eroded upland soils. These are placed in the Frio, Leona, Guadalupe, and Zavala series.

Soils and land types that are unsuited for cultivation include thin and slightly developed soils of the Zapata and Randall series and very gravelly, shallow, or eroded soils of the Maverick, Uvalde, and Webb series, together with riverwash.

Large areas of soils suited to many crops, now used mostly for ranching, afford a reserve of good land that may be utilized for farm crops, as sources of water for irrigation are developed.

The crops grown under dry-farming methods are largely those that withstand dry conditions well, such as cotton, grain sorghums, and other feed crops. The reddish-brown soils are smooth and comparatively sandy. They collect and give up soil water more readily than the other upland soils and therefore are more suited to cotton, grain, and feed crops grown without irrigation. They are also suited to these and many other crops, including truck crops, fruits, and berries, where irrigation is possible.

The production of truck crops is largely centered on the Uvalde soils and the alluvial soils in the valleys, especially the Frio soils, because of their high productivity, smooth surfaces (which favor easy cultivation), accessibility of irrigation water, and convenient location with respect to transportation facilities.

Crops yield well on the dark heavy soils of the Monteola series, and truck crops, as well as such other general farming crops as are desired, are grown successfully under irrigation.

The several thin soils unsuited to farm crops are used only for grazing.

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