U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF SOILS
IN COOPERATION WITH THE TEXAS AGRICULTURAL EXPERIMENT STATION

SOIL SURVEY (RECONNAISSANCE) OF WEST-CENTRAL TEXAS

BY

W. T. CARTER, IN CHARGE, M. W. BECK, W. W. STRIKE, B. H. HENDRICKSON, AND R. E. DEVEREUX, U. S. DEPARTMENT OF AGRICULTURE, AND H. W. HAWKER AND H. V. GEIB
TEXAS AGRICULTURAL EXPERIMENT STATION

[Advance Sheets—Field Operations of the Bureau of Soils, 1922]

UNITED STATES
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[PUBLIC RESOLUTION—NO. 9]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture"

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the Congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

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MAP

Soil map (reconnaissance) of west-central Texas

SOIL SURVEY (RECONNAISSANCE) OF WEST-CENTRAL TEXAS

By W. T. CARTER, in Charge, M. W. BECK, W. W. STRIKE, B. H. HENDRICKSON, and R. E. DEVEREUX, U. S. Department of Agriculture, and H. W. HAWKER and H. V. GEIB, Texas Agricultural Experiment Station

AREA SURVEYED

The area surveyed is in the west-central part of Texas. (Fig. 59.) It includes four tiers of counties immediately south of the area comprised in the soil reconnaissance made in the northwestern part of Texas in 1919. It is roughly a parallelogram in shape. It lies between 100° 30′ W. and 104° 00′ W. longitude, and 31° and 33° N. latitude. The area measures about 250 miles from east to west and about 130 miles from north to south, totaling 26,784 square miles or 17,141,760 acres. The 27 counties included are Andrews, Borden, Coke, Concho, Crane, Dawson, Ector, Fisher, Gaines, Glasscock, Howard, Irion, Jones, Loving, Martin, Midland, Mitchell, Nolan, Reagan, Runnels, Scurry, Sterling, Taylor (which was previously covered by a detailed soil survey), Tom Green, Upton, Ward, and Winkler.

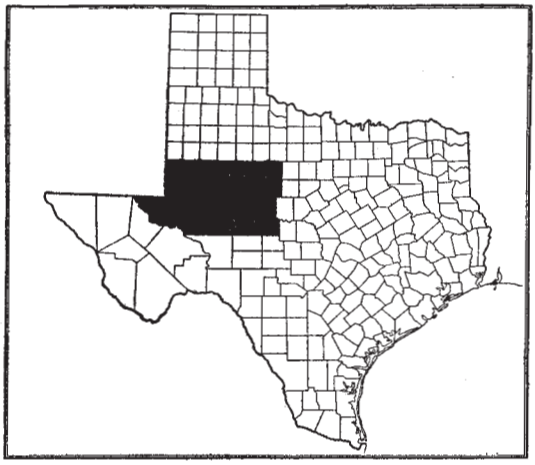

FIG. 59.—Sketch map showing location of the west-central Texas reconnaissance area

The base map used in making this survey was constructed in the field with the plane table. The roads were surveyed, and the streams, soil boundaries, and other features were mapped as the work progressed. Owing to the small scale of the map (1 inch to 6 miles) many minor variations in roads could not be shown. Generally, only the main roads are shown on the map, although in the western part mere trails are indicated, as they are of importance in local travel.

Owing to its small scale, the map does not show very small areas of soils, the main soil types and groups of soils having been outlined according to their predominance. The map is, therefore, a generalized soil map, and although many large areas of uniform soil have been outlined accurately most boundaries have been sketched only approximately. The report, however, describes in considerable detail the soils mapped, bringing out the principal variations, inclusions, and soil phases.

The object of soil reconnaissance work is to construct a map showing the predominant soils and to collect the most important data concerning them and their relation to the agricultural possibilities of the region.

County lines were usually mapped to conform with the best information available. Many western counties, in fact most counties in the area, have no boundary monuments or other definite marks. Some of them have never been accurately surveyed.

The map shows fairly accurately where the soils join those of the northwest Texas reconnaissance survey, made in 1919, except in a few places where minor changes have been made in the soil correlation since the time of the older survey. Soil areas on this map do not adjoin similar areas on the south-central Texas reconnaissance map, made in 1913. This is due to revisions in the classification and correlation of the soils which have been made since the latter survey was made.

The area lies mainly in the southern part of the Great Plains of the United States, a region that extends several hundred miles eastward from the Rocky Mountain foothills and from Canada southward nearly to the Gulf of Mexico. In general the present survey includes broad flat plains, dissected areas of very uneven or rugged character, broad rolling plains cut by shallow valleys of streams, interstream flats, and isolated table-lands or mesas which are remnants of former higher areas. For purposes of convenience in description the main physiographic subdivisions will be designated under broad regional names. The western and southern parts will be treated in two main divisions, respectively, High Plains or Llano Estacado, and Edwards Plateau. Several counties in the eastern part are within the central or eastern plains, which will be referred to as Rolling Plains[1] or Eastern Province—a region of diversified rolling plains extending over portions of Kansas, Oklahoma, and Texas.

The region has a southeasterly slope, the larger part having an elevation of 2,000 to 3,000 feet above sea level. The highest elevations are in the extreme northwestern part where the altitude is about 3,500 feet, and the lowest are in the southeast and northeast where Colorado River and the larger tributaries of Brazos River leave the area. The following table gives elevations at various points in and near the area:

[1] The term "plains" has been broadly used for the unforested region of the West where the soils are characterized by an underlying zone of accumulated lime, whereas "prairie" refers to the treeless region east of the plains, where such accumulations of lime do not occur.

Elevations at various points in and near the area

[Taken from Gannett's Dictionary of Altitudes,[1] from U. S. G. S. surveys, and from figures given by chief engineers of various railroads]

Location	Elevation	Location	Elevation
	Feet		*Feet*
Arno	2,663	Mertzon	2,184
Anson	1,708	Monahans	2,622
Abilene	1,718	Midland	2,768
Bronte	1,893	Odessa	2,889
Ballinger	1,637	Pyote	2,623
Barnhart	2,548	Pecos [2]	2,581
Blackwell	2,100	Paint Rock	1,641
Buffalo Gap	1,927	Rankin	2,494
Big Spring	2,400	North Roby	1,930
Barstow	2,573	Rowena	1,751
Colorado	2,066	Roscoe	2,387
Coahoma	2,409	Seagraves	3,342
Eden	2,025	Snyder	2,356
Hamlin	1,720	Sterling City	2,298
Iatan	2,208	Stamford	1,609
Longworth	1,963	San Angelo	1,847
Lamesa	2,978	Sweetwater	2,163
Maryneal	2,564	Toyah [2]	2,911

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

[2] Not in area surveyed, but west of Pecos River (330 feet elevation increase from Pecos to Toyah 25 miles west).

Figure 60 shows the three principal physiographic divisions of the area surveyed.

Rolling Plains.—Rolling Plains consist of areas that are gently or steeply rolling, and some hilly and eroded sections. Large bodies of smooth, flat lands occur on interstream divides, and the larger streams that cross the prairies have cut deep valleys, with numerous marginal strips of upland characterized by a rough eroded surface, such as occur in the "bad lands." Many small, narrow, and shallow stream valleys extend into all sections of the plains.

The Rolling Plains cover several entire counties and parts of others in the northeastern part of the area, comprising altogether about one-fourth of the area surveyed. The land rises from about 1,500 to 2,500 feet above sea level.

Such high plateaulike divides of flat land occur in several counties where there has not yet been much erosion. These plateaus are much lower than those of High Plains. The sides of some of these divides and stream valleys are abrupt escarpments and rolling steep slopes.

Edwards Plateau.—Edwards Plateau is in the southern and southeastern parts of the surveyed area and comprises about one-third of it. The plateau has been greatly dissected and only a few high remnants remain. There is an extensive area of the uneroded plateau in southern Nolan County on the divide between Brazos and Colorado Rivers, another of smaller extent in northeastern Sterling County on the Concho-Colorado River divide, and one, several hundred square miles in extent, in Upton, Reagan, and Glasscock Counties on the Colorado-Concho-Pecos divide. The last-named area merges on the north and west into the High Plains without perceptible change in surface configuration. Edwards Plateau varies in elevation from 2,000 to 2,500 feet.

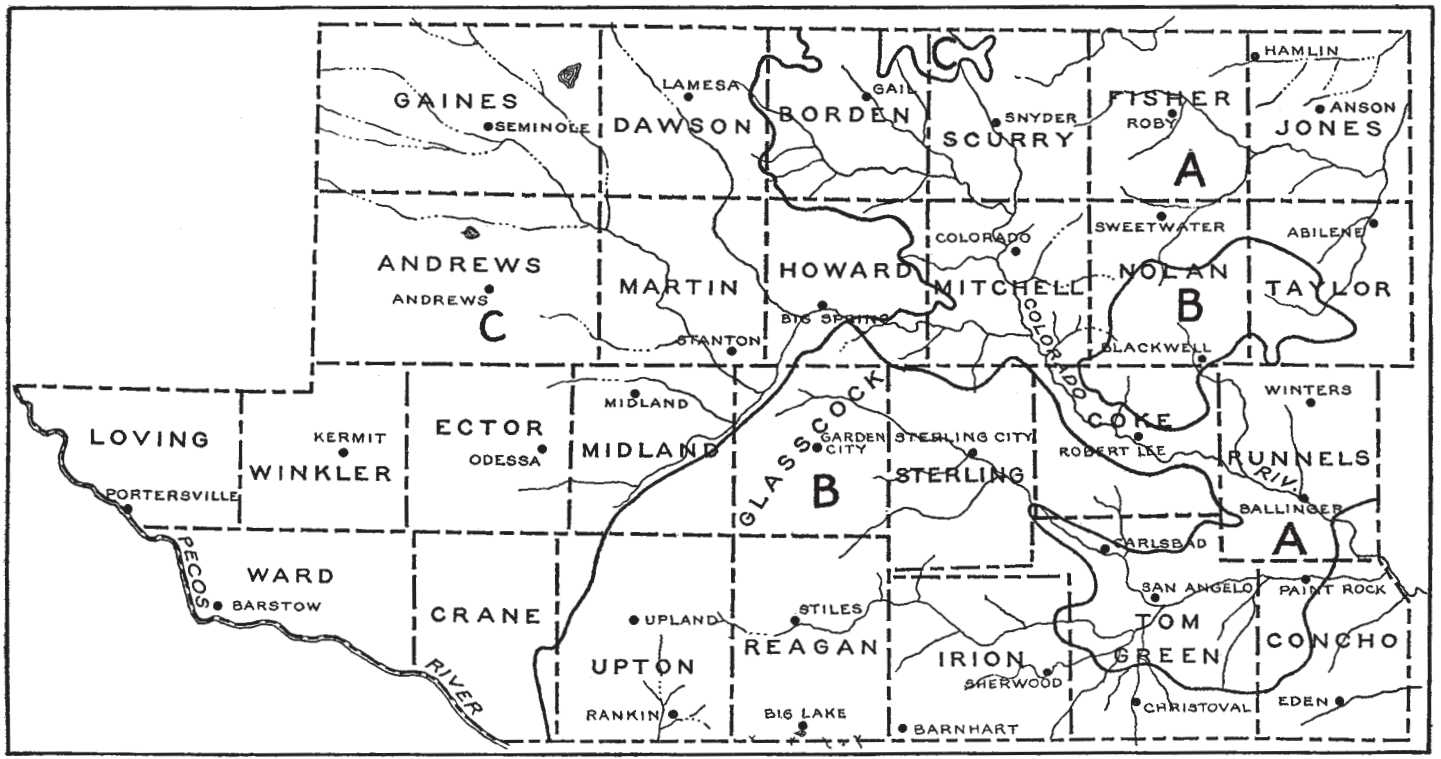

FIG. 60.—Three principal physiographic divisions of the west-central Texas reconnaissance area. A, Rolling Plains; B, Edwards Plateau; C, High Plains or Llano Estacado

The surface of Edwards Plateau is broken by deep, steep-walled canyons and valleys, conspicuous mesas, and rocky but more gentle slopes. The strips of high land bordering the higher escarpments have been severely eroded and are rugged. The escarpments themselves, some of which are several hundred feet in height, are even rougher and more stony. Small valleys extend far back into the plateau. In the upper reaches of these drainage systems, the sides of the valleys are gently rolling or sloping, but as the influence with the larger streams is approached, the valleys increase in depth and their width is sharply limited by vertical walls. In some places, small sections of the plateau have become separated by erosion, forming high mesas or buttes which constitute very noticeable features of the landscape. Larger detached bodies of several hundred square miles in extent rise from the surrounding Rolling Plains in mountainlike proportions.

The weathering of hard limestone has produced a stony surface over the greater part of Edwards Plateau and this, together with its irregularity, precludes the possibility of cultivating much of the land. Near the crest of the main areas of the plateau, and in the upper parts of the smaller watersheds, the surface is rather level and the soil contains little or no stone. These areas, together with the soil in the narrow valleys, constitute practically the only land on the plateau which is suitable for cultivation.

High Plains.—The High Plains region, frequently called Staked Plains, or Llano Estacado, is locally termed "the plains" in contradistinction to Rolling Plains or "the prairies." That part of High Plains included in the west-central Texas area and locally referred to as South Plains comprises nearly one-half the area surveyed and constitutes its most elevated portion. It includes eight entire counties and parts of six others. Its southern extension has a very gradual southwesterly slope to Pecos River, forming a drainage area ranging in elevation from 2,500 to about 3,000 feet. In the northern part, the eastern boundary of High Plains is definitely marked by a sharp, rough escarpment several hundred feet high, and continuous with the almost vertical escarpment of narrow deep canyons along drainage courses that have carved their way several miles into the High Plains. These streams constitute the headwaters of Colorado River. Toward the south, the eastern margin of the High Plains is less marked and in places merges gradually through moderately rolling and sloping areas into the Rolling Plains. On the southeastern border where the High Plains division adjoins Edwards Plateau, there is little difference in topography and elevation, but there is a decided difference in soils and vegetation.

The eastern boundary of the High Plains terminates at Big Spring at the foot of a stony escarpment, several hundred feet high, of some high remnants of Edwards Plateau. This contact of High Plains and Edwards Plateau continues southwest to the northern part of Upton County. Although it is rather indefinite in many places, there are occasional gentle slopes and slight escarpments of exposed and hardened caliche, such as characterize Edwards Plateau in Glasscock, Midland, and Upton Counties. From northwestern Upton County to northeastern Winkler County there is a distinct escarpment of something less than 100 feet in height. This extends

nearly to the southeast corner of New Mexico and the lower southwestern part of the High Plains continues to Pecos River without any abrupt topographic change.

The surface of High Plains is smooth. Much of it is flat, but a large part is undulating areas of lighter textured or sandy soils, being more undulating than those of heavy soils. The deeper sandy areas may be gently undulating, gently rolling, or billowy, having a topography characteristic of wind-blown sand.

A few drainage ways have cut canyons several miles back into the High Plains from the eastern and southern sides, thus forming a small number of narrow, shallow valleys or draws, but some entire counties are without drainage ways.

Numerous small playas, ranging in size from a few acres to about 60 acres, occur in the eastern part of the plains. Most of the playas are from 5 to 10 feet below the level of the surrounding plain, but a few are from 20 to 30 feet below. They contain water only during or after rainy seasons and dry up during the summer, sometimes remaining dry for several years. These depressions have probably been formed by the sinking of the ground. A few small lake beds are in the western portion of the High Plains region where the soils are very loose and sandy. Some large intermittent lakes occur also, which on drying leave incrustations of white salts, the largest, Cedar Lake, being in Gaines County, and Shafter and Whelan Lakes in Andrews County. These are prominent landmarks, and each of the largest two covers several sections.

A remnant of the High Plains separated from the main body is in northern Scurry and Borden Counties. It is plateaulike, with gentle slopes on all sides except the north, where it terminates in a steep escarpment just beyond the limits of the reconnaissance area.

Plate LXIII, Figure 1, shows the characteristic vegetation and undulating surface of sandy land on the High Plains.

Drainage.—The west-central Texas area is in a region of low rainfall and it is well drained throughout, but if it were in a region of heavy rainfall some of the large flat areas would suffer from inadequate surface drainage.

The largest streams are Colorado and Pecos Rivers, the former receiving the greater part of the drainage. Colorado River rises in the extreme eastern part of the High Plains in northeast Dawson County and flows southeast, leaving the area about 25 miles north of the southeastern corner. Its most important tributary is Concho River, which is formed by the confluence of North Concho, South Concho, and Middle Concho Rivers near San Angelo. Concho Rivers rise within Edwards Plateau and drain all the southern part of the area east of Odessa. These streams are fed by springs which flow continuously, and they constitute important potential irrigation waters.

The next most important tributary of Colorado River is Beals Creek, which empties into the Colorado about 15 miles south of the town of Colorado. Beals Creek is formed in the vicinity of Big Spring by the junction of Sulphur and Mustang Draws. These draws wind about in a general southeasterly direction in shallow valleys over High Plains and through Gaines, Andrews, Dawson, Midland, Martin, Glasscock, and Howard Counties. Their tributaries from various parts of these counties carry water only after

the infrequent very heavy rains. For miles from their source these draws are merely shallow depressions in the plains and in places almost disappear. They drain only a very small part of the country through which they flow, a strip probably nowhere more than a mile wide on each side, and in many sections there are no tributaries for many miles. Colorado River contains water during much of the year, though in dry seasons only scattered pools along the stream channel are present. Some irrigation water is taken from this stream, and much more could be obtained by building dams and reservoirs.

Pecos River flows for more than 100 miles along the southwest border and very few tributaries enter it from the west-central Texas area, as the rainfall is very low. Five Mile Creek, which rises in the southern part of Upton County, empties into Pecos River. A few small draws or trenchlike depressions conduct storm waters into Pecos River from the east. Most of the rainfall on the High Plains enters the ground immediately, only a small quantity going into lakes and other depressions.

Brazos River drains a portion of the northeastern part of the area through tributaries flowing east and northeast. The stream beds of the northern part have no water in them, except immediately after rains. Areas of soils suitable for irrigation occur along these streams, as along all the other streams of the Rolling Plains section, and the larger part of them could be irrigated if proper storage reservoirs and dams were provided.

Population.—The first settlements were along permanent streams in the eastern and southeastern parts. Probably the earliest were made in the early sixties along Concho River. The area was slowly settled by ranchers who gradually moved westward as available land became less plentiful in the eastern counties.

According to the census of 1880 the total population was 8,801. More than half of this was in Tom Green and Taylor Counties. In 1890 the population was 34,583, more than half of which was in the eight eastern counties. By 1900 the population had increased to 57,765, the eight eastern counties containing more than two-thirds of the total. In 1910 the population reached the maximum figure reported, 176,104. This rapid growth in population within a period of 10 years was probably the result of the settlement of State lands and the building of railroads in the West. After this boom had subsided many temporary residents moved away, so that by 1920 the population had been reduced to 152,121. The rural population in 1920 averaged slightly more than four persons to the square mile.

Settlement in all parts of the area his been slow except in the more desirable farming districts in the eastern 8 or 10 counties. The most thickly settled places are near the railroads; in fact, they are the only ones settled in the western part. A few Mexicans work on the railroads and on some of the farms, and very few negroes live in the more thickly settled eastern parts. As there are a number of towns of less than 2,500 inhabitants,[2] it will be seen that some sections are very sparsely populated. Nine counties have a population of less than 1,000 persons each.

[2] The population of all towns of less than 2,500 inhabitants is classed as rural in census reports.

The following table gives the population of the area by counties:

Population of the west-central Texas area for the census years 1880 to 1920 inclusive

County	1880	1890	1900	1910	1920
Andrews		24	87	975	350
Borden	35	222	776	1,386	965
Coke		2,059	3,430	6,412	4,557
Concho	800	1,065	1,427	6,654	5,847
Crane		15	51	331	37
Dawson	24	29	37	2,320	4,309
Ector		224	381	1,178	760
Fisher	136	2,996	3,708	12,596	11,009
Gaines	8	68	55	1,255	1,018
Glasscock		208	286	1,143	555
Howard	50	1,210	2,528	8,881	6,962
Irion		870	848	1,283	1,610
Jones	546	3,797	7,053	24,299	22,323
Loving		3	33	249	82
Martin	12	264	332	1,549	1,146
Midland		1,033	1,741	3,464	2,449
Mitchell	117	2,059	2,855	8,956	7,527
Nolan	640	1,573	2,611	11,999	10,868
Reagan				392	377
Runnels	980	3,193	5,379	20,858	17,074
Scurry	102	1,415	4,158	10,924	9,003
Sterling			1,127	1,493	1,053
Taylor	1,736	6,957	10,499	26,293	24,081
Tom Green	3,615	5,152	6,804	17,882	15,210
Upton		52	48	501	253
Ward		77	1,451	2,389	2,615
Winkler		18	60	442	81
Total	8,801	34,583	57,765	176,104	152,121

The urban population is confined to the towns of Abilene, 10,274; San Angelo, 10,050; Sweetwater, 4,307; Big Spring, 4,273; Stamford, 3,704; and Ballinger, 2,767. These towns are all important shipping and transfer points for local produce. Midland, Stanton, Colorado, Lamesa, Snyder, Bronte, Paint Rock, Hamlin, Rotan, Roby, Anson, Roscoe, Sterling, Barstow, Eden, Odessa, Mertzon, Barnhart, Big Lake, Seminole, and Winters are also fair-sized towns and important shipping points.

Transportation.—Several railroads, most of which have been built since 1900, furnish transportation for the products of the farms and ranches. They are, however, lacking in those sections, principally in the western part, where the opportunities for agricultural development are limited by unfavorable soil conditions or scant rainfall. These lands will doubtless be used for ranching exclusively for many years. Four counties are entirely without railroad facilities, and several others have only short branch lines. Some good farming lands have not been utilized because of their remoteness from railroads. A number of independent railroad lines have been constructed, but the principal railway systems now operating are Texas & Pacific; Gulf, Colorado & Sante Fe; Atchison, Topeka & Santa Fe; Kansas City, Mexico & Orient; Missouri, Kansas & Texas; and St. Louis-San Francisco.

There are a number of good highways, and several transcontinental highways which pass through the area are being rapidly improved for travel. Among these are the Bankhead Highway and others. In many counties good road-building material consisting of gravel, marl, and limestone, is abundant. Some of the eastern counties have many miles of graveled and macadamized roads; whereas in the

western counties many roads are mere trails across the plains, but they are in good condition except during unusually rainy seasons. A marl formation of chalky clay in the Edwards Plateau region has proved to be excellent road material and has been used on some roads in southern Nolan County.

CLIMATE

The climate of the west-central Texas area is mild during the greater part of the year and is very healthful. The eastern part where the altitudes are lowest has the highest temperature, and the western part on High Plains has the lowest temperature both in winter and summer. The average annual precipitation is greatest in the eastern part and least in the western part where successful farming is impossible without irrigation.

The following tables give the normal monthly, seasonal, and annual temperature and precipitation at Abilene, Big Spring, Knickerbocker, and Barstow. The first two places are in the eastern half of the area and represent climatic conditions very closely for that section. The western half has a shorter frost-free season, lower temperature, and less precipitation, and the figures for Barstow are representative for a considerable portion of this part. The data for Big Spring are fairly representative for the High Plains, and the figures for Abilene represent climatic conditions over the greater part of the Rolling Plains. Knickerbocker is in Tom Green County in the southeastern part of the area surveyed.

Normal monthly, seasonal, and annual temperature and precipitation at Abilene, Taylor County

[Elevation, 1,738 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1917)	Total amount for the wettest year (1914)	Snow, average depth
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	45.0	83	1	1.13	0.01	1.61	0.9
January	42.6	90	−5	.90	.71	Trace.	1.2
February	44.8	94	−6	1.14	1.00	.14	1.6
Winter	44.1	94	−6	3.17	1.72	1.75	3.7
March	54.9	98	16	1.38	.27	.66	.3
April	64.4	99	25	2.28	.93	5.34	.0
May	71.9	105	33	3.72	3.31	7.53	.0
Spring	63.7	105	16	7.38	4.51	13.53	.3
June	78.2	110	44	3.17	.69	1.10	.0
July	82.2	110	54	2.40	.90	1.05	.0
August	81.2	104	48	1.97	1.24	15.70	.0
Summer	80.5	110	44	7.54	2.83	17.85	.0
September	74.2	104	40	3.14	1.48	.91	.0
October	64.2	94	23	2.33	.15	4.08	.0
November	52.6	88	13	1.24	.16	3.48	.2
Fall	63.7	104	13	6.71	1.79	8.47	.2
Year	63.0	110	−6	24.80	10.85	41.60	4.2

Normal monthly, seasonal, and annual temperature and precipitation at Big Spring, Howard County

[Elevation, 2,396 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1917)	Total amount for the wettest year (1919)	Snow, average depth
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	44.2	83	−3	0.72	0.00	0.26	0.9
January	46.0	87	−4	.38	.38	.75	.3
February	48.2	94	3	.55	.00	.05	1.8
Winter	46.1	94	−4	1.65	.38	1.06	3.0
March	57.3	95	8	.81	.04	3.33	.2
April	64.6	99	23	1.71	.98	1.59	Trace.
May	73.1	109	31	2.30	.75	1.57	.0
Spring	65.0	109	8	4.82	1.77	6.49	.2
June	81.1	117	34	2.08	.88	6.83	.0
July	83.2	111	48	2.27	.81	1.01	.0
August	83.3	109	47	1.78	.03	3.42	.0
Summer	82.5	117	34	6.13	1.72	11.26	.0
September	76.1	105	37	2.41	.83	8.77	.0
October	64.9	100	26	2.24	.01	7.44	.0
November	53.8	90	7	1.12	.09	.79	Trace.
Fall	64.9	105	7	5.77	.93	17.00	Trace.
Year	64.6	117	−4	18.37	4.80	35.81	3.2

Normal monthly, seasonal, and annual temperature and precipitation at Knickerbocker, Tom Green County

[Elevation, 2,050 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1917)	Total amount for the wettest year (1914)
	°F.	°F.	°F.	Inches	Inches	Inches
December	46.6	89	2	1.19	0.00	1.01
January	48.4	94	−2	.50	.52	.15
February	50.4	94	3	.62	.14	.09
Winter	48.5	94	−2	2.31	.66	1.25
March	59.7	98	13	.80	1.10	.28
April	65.3	99	21	2.09	1.70	1.40
May	73.0	103	32	2.42	2.25	5.37
Spring	66.0	103	13	5.31	5.05	7.05
June	81.0	110	41	1.94	.42	3.76
July	83.2	111	59	1.68	.12	.63
August	82.9	109	43	2.51	.70	8.65
Summer	82.4	111	41	6.13	1.24	13.04
September	76.0	102	35	2.08	1.86	.20
October	65.8	99	21	2.10	.00	4.23
November	55.5	92	9	1.53	.25	2.67
Fall	65.8	102	9	5.71	2.11	7.10
Year	65.7	111	−2	19.46	9.06	28.44

Normal monthly, seasonal, and annual temperature and preciptation at Barstow, Ward County

[Elevation, 2,573 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1917)	Total amount for the wettest year (1914)
	°F.	°F.	°F.	Inches	Inches	Inches
December	45.2	89	0	0.65	0.00	1.46
January	47.6	89	−4	.14	.05	Trace.
February	49.7	92	6	.31	.00	.50
Winter	47.5	92	−4	1.10	.05	1.96
March	58.0	98	19	.55	.05	.02
April	64.0	99	26	.88	.05	.00
May	72.3	106	31	.60	Trace.	3.93
Spring	64.8	106	19	2.03	.10	3.95
June	81.0	114	43	.63	Trace.	.75
July	81.6	110	60	2.04	Trace.	2.14
August	80.9	111	51	1.31	1.15	2.05
Summer	81.2	114	43	3.98	1.15	4.94
September	75.6	106	39	1.50	.95	1.40
October	65.1	100	21	1.72	.00	6.59
November	53.6	96	10	.77	Trace.	1.52
Fall	64.8	106	10	3.99	.95	9.51
Year	64.6	114	−4	11.10	2.25	20.36

Precipitation is the most important climatic consideration in the area. This varies from year to year and in many years is insufficient for the production of satisfactory crop yields. The range in precipitation is shown by the records at Abilene, where in the driest year on record, 1917, the rainfall was only 10.85 inches, whereas in the wettest year, 1914, it was 41.60 inches. The mean precipitation at Abilene is 24.80 inches, and at Barstow, about 200 miles to the west, it is only 11.10 inches. Periods of dry weather sometimes continue for two or three years, and at such times crop yields are light and pasturage is scant. Normally a large proportion of the rain falls in the spring and summer; that is, during the frost-free season. The summer rains, however, are generally local, some sections having enough to mature crops when near-by sections have little or none.

Practically all precipitation is in the form of rain, the average snowfall being only about 4 inches. Hailstorms sometimes do considerable damage to growing crops, but ordinarily they are local.

The rate of evaporation of soil water, particularly from certain soils, is very high because of the comparatively high altitude, abundance of sunshine, and almost constant wind. A seven-year observation at the experiment station of the United States Department of Agriculture at Big Spring showed that evaporation from an exposed tank of water averaged 60 inches for the six-month season, April 1 to October 1. This is an average of 10 inches a month (*6*).[3]

[3] Italic numbers in parentheses refer to literature cited, p. 2131.

Over most of the area dry-land farming may be carried on with more or less success by using the most favorable soils and practicing those methods of tillage that best contribute to the storage and conservation of water.

The winters are cool and there are occasional short periods of exceptionally cold weather accompanied by "northers" (cold strong winds from the north or northwest). These cold spells sometimes develop very suddenly and frequently last several days. The summers are warm, but the heat is rarely oppressive because of the almost constant cool breezes. The nights are usually pleasant. Hot winds that are harmful to crops are rare.

The average date of the last killing frost in the spring at Abilene is March 16, and of the first in the fall, November 12, giving an average frost-free season of 240 days. Toward the west on High Plains, where the latitude is greater, the frost-free season is somewhat shorter. Late spring frosts and freezes frequently damage fruit and in some years most of the fruit crop is destroyed.

During March and April strong winds are not uncommon, and they cause the loose sandy soils to drift badly in unprotected fields, at times destroying the young crops, and making replanting necessary. Winds blow almost constantly from the south in summer and frequently from the west and northwest in winter, but except in March and April they are not so strong as to be destructive.

AGRICULTURE

The development of agriculture in the area began with the first settlement by cattlemen, who, attracted by the large tracts of free grazing lands, pushed into the eastern counties from the older settlements to the east. Even before the Civil War, soldiers were stationed at two Government forts in the section which is now Tom Green and Coke Counties, to protect the pioneers against Indian depredations.

As the first settlements were made along the larger streams where water and wood were obtainable, in the early seventies groups of cattle ranchers lived along Concho and Colorado Rivers. Small patches of alluvial soils were cultivated for the production of corn and vegetables for home use, and irrigation was practiced on a very small scale. For many years cattle raising was practically the only industry, but later, in the southeastern part of the area, sheep also were raised. The heavy growth of nutritious grasses and the free range made this area especially suitable for stock raising. As the range became more restricted in the counties to the east, the cattlemen pushed westward, until by 1880 most of west-central Texas was occupied by large ranching outfits. However, the settlement was extremely sparse except in the eight eastern counties.

During the eighties, after barbed wire had been invented, ranches began to be definitely outlined and their ownership established. In the meantime dry farming was not attempted except in the eight eastern counties. The ranchers depended solely on native grasses for feed for livestock. The cattle were driven over trails to markets, sometimes as far as Kansas, for shipment by railroad.

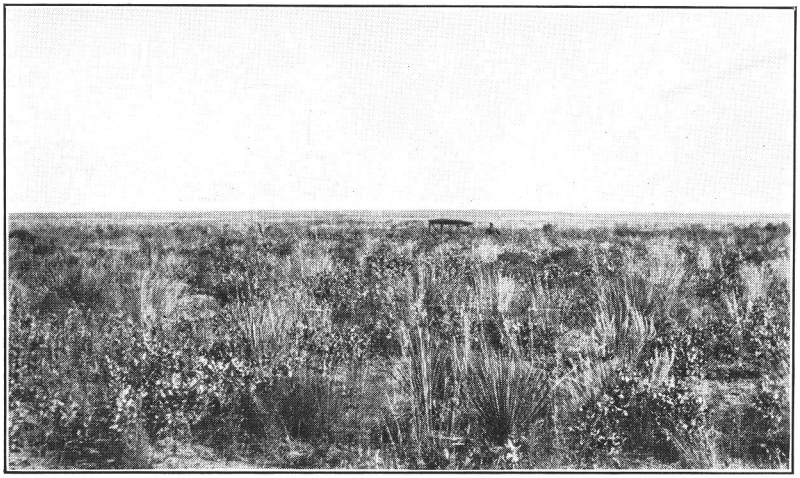

FIG. 1.—NATIVE VEGETATION ON AMARILLO FINE SANDY LOAM, LIGHT PHASE, IN GAINES COUNTY

Vegetation consists of bear grass, broom sedge, and shin oak, on slightly undulating land

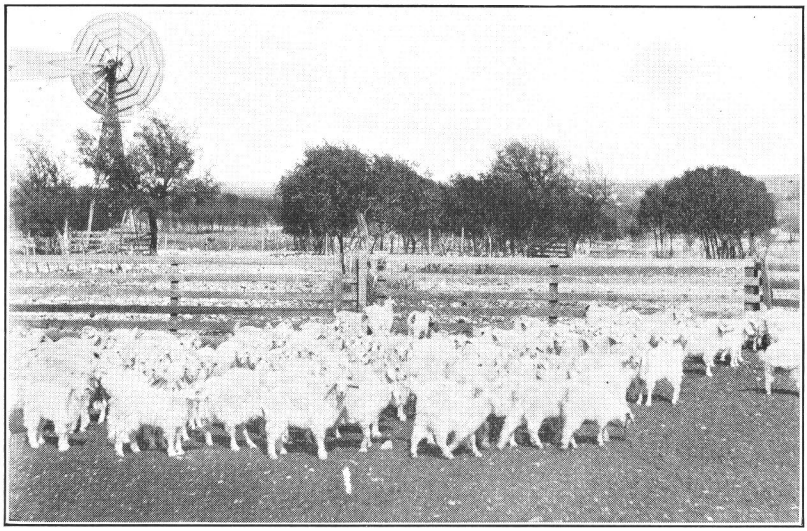

FIG. 2.—ANGORA GOATS ON VALERA STONY CLAY ON EDWARDS PLATEAU

It was also in the eighties that settlement in the region was given a decided impetus by the construction of the Texas & Pacific Railway and by the extension of the Santa Fe Railway as far west as San Angelo. A number of other railroads, built through or into the area since 1900, have aided greatly in the settlement and agricultural development. Some dry farming was begun about 1888 in the eastern part, particularly in Taylor, Jones, Fisher, Nolan, Runnels, Coke, Concho, and Tom Green Counties, and the industry has steadily increased.

Although ranching continues to be a very important industry, increasing areas are being brought under cultivation. As land becomes scarcer in the older farming regions of other States, more is put under cultivation here. Farming has been varyingly successful. Deficient moisture conditions in some years have caused temporary setbacks to agriculture, but recovery has usually followed quickly with increased

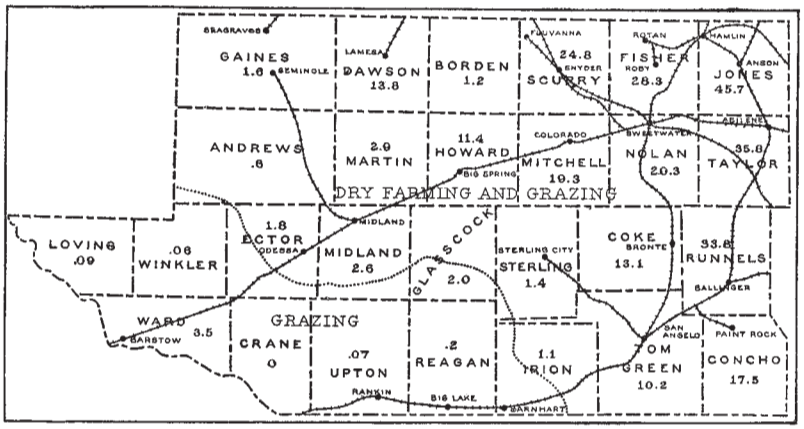

FIG. 61.—Percentage of improved land in each county in the west-central Texas reconnaissance. The dotted line shows the western limit of dry-land farming

acreages devoted to crops. The westward extension of the tilled area, particularly that of cotton, has been noticeable in recent years. At present small areas are under irrigation along Pecos, Concho, and Colorado Rivers.

Farming is carried on extensively in Taylor, Jones, Fisher, Scurry, Nolan, Tom Green, Coke, and Runnels Counties, and considerable land is farmed near railroads in Mitchell, Howard, Sterling, Dawson, Midland, Martin, Gaines, Andrews, Irion, and Ector Counties. Very little farming thus far has been done in Borden, Glasscock, Reagan, Upton, Crane, Ward, Winkler, and Loving Counties. In the last-named counties the land is used for raising stock and ranches range in size from two to several hundred sections.

Figure 61 shows the percentage of improved land in each county according to the census for 1920. The dotted line shows the western limit of the practice of dry-land agriculture.

Since general farming began, the chief crops have been grain sorghums, cotton, sorgo (sweet sorghum), and corn.

With the building of railroads and the resulting development, land values increased considerably. Much land held for $2 or $3 an acre years ago is now evaluated between $35 and $50 an acre. The price may even reach $75 in exceptionally good sections where farms are improved. Much good land may be bought in the virgin state at $20 or $30 an acre and sometimes at less. The current value of large ranches in the western part of the area ranges from $5 to $15 an acre, but some of this land is so rough, stony, or sandy as to be suitable only for grazing. The yearly rental on land leased from the State or private owners ranges from 10 to 25 cents an acre. These figures are based on prices prevailing in 1922.

The agricultural industries are chiefly livestock raising and general farming. Some enterprises are entirely devoted to farming; others to the livestock industry only; and still others combine livestock raising and farming. Since the region is peculiarly adapted to cattle raising and certain sections to the raising of sheep and goats, and since the soils and climate are especially suited to growing grain-forage crops such as sorghum, it would seem that livestock farming will eventually be carried on with the growing of forage crops and become the common practice in much of the area. It is probable that more livestock will be finished for market in certain sections, instead of being shipped to other States for fattening.

Texas Agricultural Experiment Station has a substation at Spur, just north of this area, and one near Sonora to the south. Experts at these stations specialize in the raising and feeding of cattle, sheep, and goats and investigate other phases of the livestock industry (7).

Livestock.—Cattle raising is the most important branch of the livestock industry in this area. Many ranchers own herds numbering thousands. According to the census of 1920 there were 496,363[4] head of cattle valued at $28,374,520; and in 1910 there were 599,808 head valued at $12,803,753. The increased value per head as shown by these figures was mainly the result of the demand for beef during the World War; but some increment should be ascribed, without doubt, to the fact that during the last 20 years a marked improvement has been made in the quality of range animals. The old longhorn native cattle have disappeared. Ranchers have long used purebred bulls and nearly all the herds now are of high-grade animals. Many ranchers and stockmen have entire herds of purebred animals. Hereford is the principal breed, with a few Polled Angus on some ranches and a few Brahman cattle on others.

With the fencing of land and a reduction in the size of many ranches the cattle industry has assumed a more intensive character and greater effort is made to keep the herds up to a high standard. Native grasses afford good grazing the year round, except in occasional very dry years. Most ranchers feed the cattle to some extent in winter to keep them in good condition. The amount of feed given depends largely on the condition of the stock and the range. Some ranchers, especially in the western part of the area, feed only cottonseed cake during winter, dried grass being depended on for roughage.

[4] This includes more than 50,000 head of dairy cattle. It is said that the number of cattle as given by the 1920 census is rather lower than normal as the industry had not altogether recovered from the drought of 1917–18, when so many cattle were shipped east for pasturage.

In this section very few ranchers attempt to grow forage, though a little grain sorghum and sorgo is produced. This is cut and stacked and later thrown out in bundles to the cattle. In the eastern part many ranchers raise forage for winter feeding, and some buy feed from local farmers. Most of the cattle are shipped to market at the age of 1 and 2 years.

The area of range land required for the grazing of cattle varies greatly. This is governed by the variety of grass and the density of the stands, which during some very dry seasons are sometimes so scant as to necessitate shipping the cattle to other feeding grounds. On some soils in the western part of the area, one section of land (640 acres) will provide pasturage for about 15 or 20 head of cattle; whereas on some of the better grasslands in the eastern part, one section will support from 30 to 50 head.

In the southern part, especially on the rougher lands of Edwards Plateau, cattle are frequently pastured on the same land with sheep and goats. The number of cattle grazed on a given area seems not to be restricted by the number of sheep or goats, or both, that may be grazed on the same land. Some ranchmen pasture from 50 to 75 head of cattle to the section and, at the same time, from 200 to 250 sheep or as many goats. Authorities of the State experiment station at Sonora have stated that for continuous grazing on the rough lands of Edwards Plateau there should be not more than 30 head of cattle, 150 sheep, or 60 goats to the section. It is claimed, also, that adherence to these figures reduces to a minimum the necessity for extra feeding and practically eliminates overgrazing and development of diseases through overstocking. Cattle on the very light sandy soils in the northwestern part of the area and on the stony lands in the southern part feed on small shin oak brush when grass is scant.

According to the census of 1920 there were in the west-central Texas area 54,281 head of dairy cattle, valued at $3,069,292. These were principally in the eastern part, where the rural population is thickest and where there are large towns. These towns are supplied by the small dairies and cream is shipped to outside markets. In 1919, 7,188,485 gallons of milk were produced, and receipts from the sale of dairy products were $306,080. Most of the dairy products sold were from Fisher, Howard, Jones, Nolan, Runnels, Taylor, and Tom Green Counties.

The sheep industry is second to cattle raising in importance, there being in the area, according to the 1920 census, 421,429 head, valued at $5,628,395. This valuation is somewhat greater than normal, as sheep comanded a very high price at that time. Tom Green and Irion Counties constitute the most important sheep-ranching section, although large numbers of sheep are raised in Coke, Concho, Howard, Nolan, Reagan, Runnels, Sterling, and Upton Counties, and a few flocks in most of the other counties. Sheep raising is confined largely to the Edwards Plateau region, where much of the rougher lands are utilized for this purpose. Sheep are raised principally for wool, but some are shipped for mutton. The principal breeds are Rambouillet and delaine Merino, and some Shropshires are raised in the southeastern part of the area.

The production of wool and mohair is a very important industry in the southern part, and these products are sold through cooperative agencies having warehouses at Ballinger, San Angelo, Mertzon, Sterling City, Barnhart, and Big Lake. The high price of wool during the World War led many ranchers to increase the size of their flocks, thereby overstocking the range. Recent losses of sheep because of stomach worms and other diseases are attributed to this overstocking.

Goats have been raised in the southern counties for many years, and during the last 20 years the common Mexican breeds have been improved by crossing with Angora goats. Herds of Angora goats are kept for the production of mohair, but Mexican goats are raised largely for meat. The mohair produced by Angora goats is of very high quality and brings a much higher price than wool. The goats feed on the brush and undergrowth of rougher stony lands and on the leaves of small shin oak and live oak trees. When goats are grazed on the same land as sheep and cattle they improve the growth of grass by clearing out the underbrush. They thrive on the rougher lands, and, considering the value of mohair, it would seem that the goat-raising industry might be profitably extended. Plate LXIII, Figure 2, shows a herd of young goats on stony areas of Edwards Plateau.

Horses and mules are not raised in such large numbers now as formerly, when more were required in the cattle industry. Farmers and ranchers raise a few for home use and local sale.

The counties having the most farms produce the greatest number of hogs. These are Coke, Concho, Dawson, Fisher, Jones, Mitchell, Nolan, Runnels, Scurry, Taylor, and Tom Green Counties. Many farmers produce pork for sale in addition to that needed for home use. The region is well suited to hog raising, but until recently there has been no production on a large scale. Duroc-Jersey and Poland-China are the principal breeds.

Although a number of poultry farms are operated in the eastern part, as a rule poultry raising is carried on with other farm activities. Large flocks of chickens and turkeys are kept on most farms to supply home demands, and many farmers have a surplus of chickens and eggs and some turkeys for sale. Most poultry is of common stock, but many purebred flocks are maintained.

General farming.—The variety of agricultural products grown within the west-central Texas area is not great. The greater part of the farmed land is "dry-farmed," irrigation being practiced only on a few small areas. The western part does not get sufficient rain for dry farming, except in the northwest, where soil conditions are peculiarly favorable for the growth of plants, even in very dry seasons. The crops comprise principally grain sorghums and cotton, with smaller amounts of wheat, oats, and forage crops, consisting mainly of sorgo, Johnson grass, Sudan grass, and alfalfa. Most farmers produce some vegetables and fruits for home and local use, but these are seldom grown commercially.

The following table, compiled from the census reports, gives the total acreage of land, the improved land in farms, and the percentage of improved land in the area, by counties, in 1920:

Land area, improved land in farms, and percentage of improved land, by counties, in 1920

County	Area of county [1]	Improved land in farms	Improved land	County	Area of county [1]	Improved land in farms	Improved land
	Acres	*Acres*	*Per cent*		*Acres*	*Acres*	*Per cent*
Andrews	1,001,600	6,189	0.6	Midland	567,680	14,899	2.6
Borden	572,800	24,496	4.2	Mitchell	566,400	109,318	19.3
Coke	595,840	78,230	13.1	Nolan	563,200	114,621	20.3
Concho	587,520	103,176	17.5	Reagan	685,440	1,541	.2
Crane	561,920	2	--------	Runnels	693,120	234,498	33.8
Dawson	577,920	79,864	13.8	Scurry	567,680	140,886	24.8
Ector	570,880	10,451	1.8	Sterling	606,720	8,602	1.4
Fisher	566,400	160,610	28.3	Taylor	581,120	208,561	35.9
Gaines	985,600	16,103	1.6	Tom Green	930,560	95,530	10.2
Glasscock	554,240	11,125	2.0	Upton	764,800	582	.07
Howard	570,240	65,363	11.4	Ward	529,280	19,051	3.6
Irion	638,720	7,604	1.1	Winkler	540,160	366	.06
Jones	590,080	269,682	45.7				
Loving	481,920	456	.09	Total	17,030,400	1,799,001	10.5
Martin	578,560	17,195	2.9				

[1] Census figures for 1920.

Only a little more than 10 per cent of the land in the area is improved land in farms. The 10 most eastern counties comprise less than one-third of the total, but they contain more than 80 per cent of the improved land.

The following table, compiled from the census reports, gives the acreage and production of the principal crops in 1919, by counties:

Acreage and production of principal crops in 1919, by counties

County	Cotton		Corn		Oats		Wheat		Grain sorghums		Hay and forage	
	Acres	*Bales*	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Tons*
Andrews			2,651	30,196					37	370	1,481	5,244
Borden	3,820	1,412	574	8,097	49	585	150	1,280	6,837	163,254	4,492	7,345
Coke	28,183	11,270	3,085	64,035	10,152	275,471	1,935	25,260	7,724	186,182	7,616	9,801
Concho	34,355	15,814	3,153	80,308	9,121	228,326	3,368	48,237	3,717	104,820	16,364	29,382
Dawson	24,249	9,447	6,660	112,305	19	279	141	1,710	18,024	476,357	11,771	15,002
Ector	363	54	88	951							1,976	1,638
Fisher	82,499	43,152	3,504	72,785	7,592	206,266	16,959	241,861	15,413	450,743	21,335	27,154
Gaines	485	97	3,762	39,458					1,058	20,483	4,282	3,301
Glasscock	1,055	241	212	3,185			233	3,325	1,374	19,517	2,571	2,674
Howard	24,875	7,349	2,275	35,129	318	4,795	1,168	8,816	12,993	334,706	7,983	10,572
Irion	2,040	632	301	7,084	438	13,240	69	1,312	15	460	3,170	3,120
Jones	124,871	66,543	4,111	86,173	18,035	698,182	32,885	499,057	44,260	1,399,097	15,231	23,003
Loving	72	27									251	583
Martin	6,659	1,340	410	4,771					207	2,960	6,664	4,989
Midland	4,626	951	83	948					30	450	6,699	5,987
Mitchell	45,712	20,655	3,440	60,798	764	11,855	709	6,449	17,395	521,755	14,873	18,130
Nolan	35,875	18,124	1,900	43,591	4,181	110,903	4,366	54,300	19,845	669,829	12,011	17,794
Reagan	5	5	73	1,246	18	300			300	5,700	675	707
Runnels	86,976	43,660	3,626	94,334	35,669	1,201,876	24,405	422,996	39,374	1,522,743	16,782	27,019
Scurry	42,275	18,981	2,997	51,417	1,530	27,015	6,008	64,206	32,929	812,502	17,695	31,474
Sterling	649	166	304	6,527			20	280	861	10,912	2,876	6,653
Taylor	70,952	38,190	3,018	71,688	23,263	807,257	34,312	638,097	29,511	904,889	14,294	20,531
Tom Green	25,371	11,182	1,600	38,204	8,257	171,689	4,280	55,605	9,367	335,943	15,744	24,791
Upton	2	1	20	125							408	887
Ward	10,136	4,095									3,915	7,538
Winkler			11	55					3	50	62	17
Total	656,105	313,388	47,858	913,410	119,406	3,757,989	131,608	2,072,791	261,274	7,943,722	211,221	305,336

These figures represent rather high acre yields of the various crops when compared with those of other years, as the rainfall during 1919 was heavier than normal.

Cotton.—The area of land devoted to cotton production is rapidly increasing. During the last 10 years the acreage in some counties has increased by many thousands of acres. The climate and many soils of the region are well suited to cotton growing, although in some years rainfall is insufficient to produce a large crop. The boll weevil is not and, it is believed, will never become a serious menace to the crop here. Most of the cotton is grown without irrigation. In the eastern counties the crop averages one-half bale to the acre, though on some farms the yields may be much higher. Mebane cotton is the leading variety grown, though other varieties are grown by some farmers.

Several thousand acres are planted to cotton on irrigated land in Ward County along Pecos River and in some of the southeastern counties along Concho Rivers. Here yields are higher than in non-irrigated sections. Experiments at Lubbock [5] show that it is profitable to grow cotton on the High Plains on selected soil. Results of experiments covering a 10-year period at this station show the average yearly production of lint cotton as 348.87 pounds an acre (*4*). This period of 10 years included 2 in which the rainfall was very light.

The Office of Dry Land Agriculture of the Bureau of Plant Industry, United States Department of Agriculture, maintains an experiment station at Big Spring near the south border of the High Plains and almost in the center of the area surveyed. This station has been in existence seven years and, according to unpublished records of experiments, the results seem to indicate as favorable production of cotton in that section as at the Lubbock station. These records (*6*) show for the seven-year period average yields of 600 pounds of seed cotton to the acre, although in two of those years the rainfall was so light as to cause an absolute failure in cotton production. Plate LXIV, Figure 1, shows a field of good cotton that has been subjected to a long period of drought.

Grain sorghums.—Grain sorghums constitute the crop second in importance. These sorghums adapt themselves well to moderate rainfall and for this reason they, rather than corn, have been the principal grain and forage crop. They are grown on nearly every farm. For many years milo and kafir have been the principal sorghums grown. Milo is grown more extensively at present, for it is said to give larger yields of grain than kafir; but the forage from the latter is more abundant, of better quality, and livestock relish it more. Considerable feterita also is grown, although heretofore it has not met with much favor, owing to the tendency of the grain to shatter before harvest. A new variety of feterita known as Spur feterita (Pl. LXIV, fig. 2), originated by the Texas Agricultural Experiment Station (*2*), is gaining in popularity. It yields somewhat more than either milo or kafir and does not shatter so badly. Small quantities of other sorghums also are grown. In 1919 the average yield was about 30 bushels to the acre. According to experiments

[5] Lubbock Substation No. 8, Texas Agr. Exp. Sta., is located about 50 miles north of the northwestern part of this area. It is on the High Plains at an altitude of 2,800 feet.

made for seven years at the Big Spring station of the United States Department of Agriculture, the average production of grain sorghum was about 25 bushels an acre (*6*), and two of those years were extremely dry. Most of the grain sorghum is grown without irrigation.

Grain sorghums are used for both grain and fodder, and small quantities are sometimes used for silage. The farm livestock of the area is dependent on these sorghums for their grain feed. Very little of the grain is shipped out, as the production is seldom more than is required locally. Some farmers cut and bind the sorghum into bundles and stack it for later feeding; but many farmers simply harvest the heads, then turn livestock in to graze the forage. The latter method seems rather wasteful, as considerable forage is trampled into the ground or damaged by wind and rain.

Owing to the suitability of grain sorghums for fattening cattle, as established in general practice and proven by experiments conducted by the Texas agricultural experiment station at Spur (Bul. 296, Texas Agr. Expt. Sta.), it appears that the local fattening of west Texas beef cattle may become an important business and furnish a good market for larger amounts of the grain sorghums grown in the region.

There are a few silos in some sections. Silage is fed to milk cows in the winter, but is considered unprofitable feed for beef cattle.

Grain sorghums are usually planted about the first of April if moisture conditions are favorable, but may be planted any time during the spring and early summer, with a fair chance of yielding a crop even when planted as late as July 15.

Corn.—Corn succeeds best on the alluvial soils; the next best results are obtained in upland depressions and on flats where the soil is deep; and sloping areas of shallow and eroded soils give the lowest returns. Sandy soils with clay subsoils seem to be best for the crop. In the northwestern part of the area, in Dawson, Gaines, and Andrews Counties, considerable corn is grown on soil of this character.

Throughout the region some corn is planted, but the crop is uncertain, because of frequent drought at critical times in the spring and summer. It would, therefore, seem more practicable to plant drought-resistant sorghum, since the food value is about the same. Yields in this section, though not high, seem fairly certain, and a considerable acreage is devoted to corn, which gives to the western counties some local prominence in corn production. The principal varieties grown are Surecropper, Chisholm, and yellow dent strains.

Small grains.—In the eight counties in the most eastern part of the area oats are sometimes grown rather extensively, but in years of unfavorable moisture conditions only a small acreage is devoted to the crop. Yields vary considerably according to the kind of soil and the season. On sandy and shallow soils, very small yields are obtained; but on deep, heavy upland soils, yields have reached 80 bushels or more an acre in favorable seasons.

Oats are generally seeded late in the fall and afford some winter grazing for livestock. Like wheat, they are harvested in May or early June. Red Rustproof (Texas Red) is the principal variety grown.

Wheat is grown in practically the same sections as oats, on about the same number of acres. The four leading wheat counties are Taylor, Jones, Runnels, and Fisher. Like oats, wheat yields are best on the smooth, deep, and heavy upland soils. In favorable seasons yields range from a few bushels an acre on thin light soils to 25 bushels or more on the heavy soils. The average for 1919, which was a fairly good season, was approximately 15 bushels to the acre. Seeding is usually done in the fall, though some spring wheat also is sowed. Mediterranean and Turkey are the principal varieties grown. A number of local flour mills use nearly all the crop.

Some barley and rye are grown in some of the eastern counties. From 15 to 30 bushels to the acre are obtained if the rainfall is sufficient. The crop is generally pastured, but in exceptionally good seasons the matured grain is harvested and used for feed.

Forage crops.—Forage crops, though grown on only small acreages, are important crops grown on practically every farm to furnish roughage for the farm work stock and milk cows. The chief forage crop is sorgo (saccharine sorghum), which is well suited to the soils of the region.

Miscellaneous crops.—In the eastern counties many farmers have small fields of peanuts which give good yields on the sandy soils, but they are not grown on a commercial scale. The vines are sometimes utilized for hay and the nuts are valued as hog feed, the hogs being turned into the fields to forage.

Some broomcorn is grown by a few farmers with sufficient success to show that it could be grown extensively if there were a sufficient demand for the product to make it profitable.

Soils of this area are, on the whole, good for the production of vegetables. With favorable moisture conditions, nearly all the common vegetables grow well and yields are excellent, especially on the lighter soils. Aside from the market gardens which supply the larger towns, vegetables are not grown on a commercial scale; but pratically all farmers and ranchmen have small gardens of vegetables for home use. The principal vegetables produced and sold locally are sweet potatoes, watermelons, cantaloupes, tomatoes, spinach, peppers, and beans. Many farmers and ranchers irrigate their gardens with water drawn from wells by windmill pumps, and some in the southeastern counties irrigate from flowing streams. Plate LXV, Figures 1, 2, and 3, show sweet potatoes, watermelons, and beans grown on the High Plains without irrigation.

Various fruits grow well on many soils in the area, but because of late frosts fruit crops are somewhat uncertain. According to local information, a crop is obtained about three years out of five. Not much fruit is grown for commercial purposes, most of it being in small home orchards, but a surplus finds a ready market in neighboring towns. A few farmers irrigate their orchards, but usually the rainfall is depended upon for the moisture supply. The fruits commonly grown are peaches, plums, apples, grapes, pears, and berries.

One orchard of about 60 acres containing peach, apple, plum, and pear trees is located on Amarillo fine sandy loam, shallow phase, in southern Gaines County, and is reported to have produced fruit every year since coming into bearing.

Pecan trees in profusion grow wild on many stream bottoms in the southeastern part, and some attention is being given there to the production of improved or paper-shelled varieties.

Markets for produce.—A large proportion of the farm products is shipped to outside markets. The production of wheat and oats is confined to the eastern counties and to years of sufficient rainfall. Wheat is ground into flour at local mills, but the oats in excess of local needs are shipped out of the area. Cotton is sold to local buyers and local oil mills use the cottonseed. Part of the livestock is shipped to packing houses at Fort Worth or Kansas City. Large numbers of young cattle are sold as feeders in Kansas, Iowa, and other corn States, but some cattle are fattened in pens at the oil mills. Wool and mohair are stored locally in the sheep-and-goat district in the southern part, to be sold later to buyers from large wool markets. Sorghum is used mostly as feed for farm and ranch livestock and the surplus is sometimes shipped to other parts of the State. Practically all dairy products in excess of home requirements are utilized locally in creameries and ice-cream factories. Much of the butter used in the larger towns is shipped in from outside. Vegetables in small quantities are grown for local town markets, but a great deal of market-garden produce is shipped in from various parts of the country.

Crop and soil relations.—The relation of soils to crops and the adaptation of certain crops to certain soils have been learned by accident or by experiment during the last 20 years. Although the most important question is that of adequate moisture, the question of the adaptation of crops to soils can not be entirely disregarded.

Large areas of rough stony land and rough broken land and moderately broken areas of various soils, as well as Valera stony clay, are obviously unfit for cultivation and are utilized solely for grazing. Shallow and gravelly soils occurring most extensively in the western part of the area are either unfit for cultivation or not suitable for crop production, because of their inability to hold the small amount of moisture available. Ector gravelly loam, Reeves gravelly loam, Reagan gravelly silty clay loam, and Reeves chalk, although occurring in comparatively smooth areas, are not worth cultivating, and native grasses afford only fair grazing. Ector gravelly loam and Reagan gravelly silty clay loam, being farther east and receiving more rainfall than Reeves gravelly loam and Reeves chalk, support somewhat more grass. A number of soils of good depth and apparently fair productiveness occur in the western part, but are not cultivated on account of the scant rainfall during most years. These are Reagan silty clay loam, Amarillo loamy fine sand, and Reeves fine sandy loam. As irrigation has not as yet seemed feasible, these soils are utilized for pasturage. Small areas of Reeves fine sandy loam around Barstow are irrigated from Pecos River and utilized for the production of cotton, alfalfa, and some oats and wheat. An area in the vicinity of Grand Falls is also irrigated and used for the production of cotton.

A large area of dunesand in the western part is utilized only for grazing, as the sand is so deep and loose that much of it drifts in the winds. With the usual light rainfall these sandy areas can not therefore be safely cultivated. Another group of soils unsuitable for

cultivation are shallow soils or shallow phases of soils that are fairly productive. These are Abilene clay loam, shallow phase; Valera clay; Amarillo loam, shallow phase; and Vernon clay loam. Although very small areas of some of these soils are now and then cultivated for grain sorghums and cotton, even a moderate yield can not be expected except in a year of reasonably heavy rainfall well distributed throughout the frost-free season.

It is well understood that heavier soils are better suited to the production of wheat and oats than are the coarser-textured soils, as fine sand and fine sandy loam, which are more suited to the production of vegetables and fruits. The production of cotton, grain sorghum, corn, sorgo, and alfalfa in this area is more dependent on moisture conditions than on the texture of the soils, although in seasons of adequate rainfall yields from all these crops are greater on the finer-textured soils and decrease as the texture becomes coarser.

The fact that cotton is the one cash crop of the area leads to its cultivation on practically all the tillable soils where the moisture supply may be sufficient to produce a crop. It is recognized that the soils best suited for cotton production under the conditions which prevail are alluvial, level, bottom-land soils of the Miller, Spur, Frio, and Yahola series. These soils, though not extensive, are largely under cultivation. They are utilized for cotton, sorghum, and corn. Some irrigation is done with considerable increase in yields of all crops raised. Alluvial soils along Pecos River could be irrigated, although some of them are rather high in alkali. Roscoe clay, Abilene clay loam, Abilene silty clay loam, Amarillo clay loam, Valera clay, and Miles clay loam are extensive, deep, strong upland soils on smooth and nearly level land that is utilized to considerable extent for cotton, corn, sorghums, and, in places, for wheat and oats. These soils are recognized as being rather well suited to the production of these crops even in dry seasons, provided there is a fairly good supply of moisture in the soil in spring and thorough cultivation is given throughout the growing season.

Fine sandy loam also is utilized for cotton, corn, and sorghums, These are Amarillo fine sandy loam, Miles fine sandy loam, Vernon fine sandy loam, and Vernon very fine sandy loam. These soils, although sandy on the surface, have rather heavy subsoils and are drought resistant. The farmers recognize their suitability to the crops mentioned and the comparatively favorable moisture retention which prevails in these soils, especially in areas where depressions are present.

Lighter-textured soils, such as Amarillo fine sandy loam, light phase; Miles fine sand; Miles fine sand, shallow phase; and Richfield loamy fine sand, are recognized as being fairly productive soils, with good drought-resisting qualities. Amarillo fine sandy loam, light phase, is rather widely used for corn production.

The group of heavy soils most unsuitable for cultivation, principally on account of unfavorable topography, are Richfield silty clay loam, Miles clay, Miles clay loam, rolling phase, Vernon clay, and Vernon clay loam. Farmers recognize the suitability of these soils for the production of cotton, sorghums, and small grains, but realize that the slopes allow much rain water to escape. Randall clay is not utilized because of its occurrence in depressions where water collects after rains.

Crop rotation.—Although farming has been carried on for a considerable length of time in the eastern part of the area no definite system of crop rotation has been worked out and generally practiced. However, certain rotations which are fairly well established in regions farther east may be applicable here. Specific information concerning crop rotation in the Great Plains region may be obtained from the Texas Agricultural Experiment Station and from the United States Department of Agriculture, as these organizations maintain substations for experimental work at various points.

Texas State Substation No. 7, at Spur, has data especially applicable to the soils and climate of the eastern counties, and at substation No. 8, at Lubbock, experiments have been made under conditions similar to those existing in the High Plains. The United States Department of Agriculture operates an experiment station at Big Spring near the center of this area, and results obtained there should be applicable to a very large part of it.

Need for crop rotation may become increasingly urgent with continuous cropping, although the history of farming in many dry regions has shown that the soils are of lasting productivity.

Farm practices.—With the exception of small irrigated areas in several of the counties in the southeast and two small areas in Ward County in the west, practically all the farming is done according to dry-land methods. Therefore, as west-central Texas lies within the subhumid region where rainfall is sometimes deficient, the main problem is to select crops that are drought resistant and to treat the soils in such a way as to collect and conserve all the moisture available. Frequent shallow cultivation is practiced to destroy weeds and grass and to prevent loss of moisture by evaporation; and it is recommended that land be plowed in the fall or winter to assist the absorption of rain water.

According to experiments made by the United States Department of Agriculture in the Great Plains region (*1*), the practice of allowing land to lie idle in alternate years and the practice of frequent tillage have not proved so profitable as growing a crop every year.

The methods of cultivation vary somewhat with the kind of soil. The strong spring winds drift the lighter sandy soil into piles or sweep it across cultivated fields, covering or cutting off young plants. This difficulty is partially overcome by leaving the land in listed beds or by plowing double furrows at right angles to the direction of the wind during sand storms. Heavier soils, such as clay and clay loam, as well as some fine sandy loam, are sometimes damaged by dashing rains which wash much of the surface soil from the steeper slopes. In some eastern counties a number of farmers have terraced their rolling lands to prevent erosion.

To meet the droughty conditions, some farmers, notably in the High Plains, practice the "skip-row" method in planting cotton and grain sorghums. (Pl. LXVI, fig. 1.)

Labor and tenure.—Most farms are operated and worked by the owner during the greater part of the year. Extra labor is required for chopping and picking cotton and for harvesting grain sorghums and small grain. Farm laborers are easily available and in the year of the survey (1922) were paid from $30 to $40 a month, with board. Mexicans and negroes are paid for picking cotton at the rate of

about $1.25 a hundred pounds. Day labor ranges from $1.50 a day to considerably higher in harvest time. Mexicans are generally employed as sheep herders at a wage of about $35 a month, without board. Ranch laborers, who are almost all white Americans, are paid from $30 to $50 a month, with board.

According to the census of 1920, about 62 per cent of the farms (including ranches) were operated by their owners. A larger proportion of ranchmen than farmers operate their own holdings.

By consulting the following table, tenure conditions may be noted. Counties containing the most farms show a higher percentage of tenant occupation. In Jones, Taylor, Runnels, Scurry, and Nolan Counties more than 50 per cent of the farms are operated by tenants, and in Coke, Fisher, Mitchell, and Ward Counties the percentage is only slightly lower. In Ward County, which contains large ranches, an apparent exception to this rule exists, owing to the fact that the irrigated lands along Pecos River are subdivided into small farms. Farm rentals are mostly on the share basis, the owner receiving one-third of the grain and one-fourth of the cotton produced. Large tracts of ranch land are leased from the State, railroads, and private owners, rentals ranging from 10 to 20 cents an acre.

The size of farms in the area varies considerably. The ordinary size in the farming sections is about 160 acres. The ranches may vary from 2,000 to 10,000 acres, and a few contain more than 100,000 acres.

The following table shows by counties the percentage of land operated by owners, managers, and tenants and the size and number of farms in the several counties, according to the 1920 census:

Tenure and size of farms in 1920

County	Proportion of farms operated by—			Size of farms			Total number of farms
	Owners	Managers	Tenants	Less than 260 acres	260 to 999 acres	1,000 acres and over	
	Per cent	*Per cent*	*Per cent*	*Number*	*Number*	*Number*	*Number*
Andrews	77.2	0.0	22.8	6	13	38	57
Borden	57.4	2.5	40.1	60	68	69	197
Coke	51.9	.8	47.3	392	228	101	721
Concho	52.8	1.4	45.8	356	229	63	648
Crane	87.5	.0	12.5	0	0	8	8
Dawson	65.9	.1	34.0	259	278	37	574
Ector	83.6	3.7	12.7	12	15	28	55
Fisher	51.3	.3	48.4	1,136	357	48	1,541
Gaines	73.6	8.5	17.9	8	38	94	140
Glasscock	67.0	8.9	24.1	8	28	76	112
Howard	58.5	1.9	39.6	210	159	53	422
Irion	70.6	2.2	27.2	55	25	56	136
Jones	42.3	.7	57.0	2,225	337	24	2,586
Loving	78.6	7.1	14.3	5	1	8	14
Martin	68.3	.0	31.7	50	51	38	139
Midland	64.7	.0	35.3	42	32	59	133
Mitchell	51.6	.3	48.1	610	217	37	864
Nolan	46.8	1.2	52.0	664	298	53	1,015
Reagan	63.0	10.9	26.1	3	6	37	46
Runnels	45.8	.3	53.9	1,593	380	50	2,023
Scurry	47.1	.3	52.6	669	351	57	1,077
Sterling	67.2	5.3	27.5	22	36	73	131
Taylor	47.7	.4	51.9	1,502	343	47	1,892
Tom Green	54.3	2.9	42.8	374	209	97	680
Upton	74.2	.0	25.8	1	1	29	31
Ward	50.4	1.7	47.9	198	15	25	238
Winkler	81.5	14.8	3.7	0	0	27	27
Total	62.3	2.8	34.9	10,460	3,715	1,332	15,507

The price of land varies considerably, owing to great differences in soil and climatic conditions. In irrigated sections and especially favored dry-farming districts, such as productive creek bottoms, improved land at this time (1922) is held at $75 to $100 an acre. In the eastern part of the area, land suitable for farming ranges in value from $25 to $50 an acre for improved land, and from $15 to $25 for unimproved land. In the western counties current values range from $10 to $20 an acre, although some land composed of shallow soils may be bought for considerably less. Rough, untillable grazing lands bring from $5 to $20 an acre.

NATIVE VEGETATION [6]

The native vegetation of the area consists chiefly of grasses and a few small trees. Owing to the lack of time during the survey for making detailed systematic studies of the plant growth, some work was done in noting incidentally the kind of vegetation on the various soils and in identifying the plants on the virgin soils and the predominant plants in communities on each type of soil. Specimens of the most dominant plants were collected in the field and identified.[7]

In the detailed discussion of the various soil types and phases, the most important and characteristic native plant growth for each soil is given. An attempt is here made to classify or group the native plants according to plant communities, as was done by H. L. Shantz in his investigations of the relation of native vegetation to soils in the semiarid regions of western United States.

Plant communities show marked predilections for certain soils, and changes in soils are suggested by changes in vegetation. The availability of soil moisture seems to govern largely the soil selection of the plants. This seems to be generally true throughout the semiarid region, and is evidenced in the general distribution of the vegetation in this area. In the eastern part, where the average rainfall is approximately double that of the extreme western part, the vegetation is thicker and ranker. As one moves westward he finds the coarser vegetation, the tree growth especially, becoming somewhat smaller. On the moist bottom lands of the valleys in the eastern part, there is a considerable growth of small trees similar to characteristic bottom-land trees hundreds of miles east of this area where the rainfall is considerably greater. This vegetation on humid soils consists mainly of hackberry, box elder, elm, pecan, and wild chinaberry.

Associated with this type of vegetation are a small number of mesquite trees which naturally belong to the semiarid types of vegetation, and which consistently and commonly occur in the semiarid region of Texas. Trees of the humid type gradually disappear toward the west, and the mesquite grows more abundantly and takes the place of those trees almost completely in the bottom lands west of meridian 100° 30′. Apparently the mesquite, a dry-country tree, responds to favorable moisture conditions and attains its largest

[6] Acknowledgment is hereby given H. L. Shantz, Bureau of Plant Industry, United States Department of Agriculture, for notes and suggestions in the preparation of the chapter on Natural Vegetation.

[7] The grasses were identified by A. S. Hitchcock, and most of the other plants by S. F. Blake, Bureau of Plant Industry.

and thickest growth on the deeper valley soils, and on flat or depressed areas where the soils are deepest and most favorably situated for the collection of moisture. Doubtless the mesquite would be more prominent in the eastern bottom lands if it were not for its being crowded out by trees of the humid type. Mesquite forms only a very thin and scrubby bush growth in the farthest western parts of the area and is entirely absent on some of the deeper sandy soils where moisture conditions favor the better development of other plants which grow in such abundance as to choke out the mesquite.

The following list includes the more important grasses and shrubs growing within the area surveyed:

Adobe grass, sometimes locally known as wire grass and vine mesquite grass	(*Panicum obtusum*).
Alfileria, sometimes shortened to filleree	(*Erodium texanum*).
Algerita	(*Odostemon sp.*).
Allthorn	(*Kocberlina spinosa*).
Bear grass	(*Yucca angustifolia*).
Blackbrush, sometimes called tarbush	(*Flourensia cernua*).
Black grama	(*Bouteloua hirsuta*).
Blue grama	(*Bouteloua gracilis*).
Blue stem, or broom sedge	(*Andropogon scoparius*).
Blueweed sunflower, commonly known simply as blue weed	(*Helianthus ciliaris*).
Jointfir, locally known as Brigham tea	(*Ephedra sp.*).
Buffalo grass	(*Bulbilis dactyloides*).
Bunch grass	(*Andropogon sp.*).
Burrow grass	(*Scleropogon brevifolius*).
Catclaw	(*Acacia sp. and Mimosa sp.*).
Club-rush or dwarf club-rush	(*Eleocharis palustris*).
Creosote bush	(*Covillea tridentata*).
Crotonweed	(*Croton texensis*).
Curly mesquite-grass	(*Hilaria belangeri*).
Golden-aster	(*Crysopsis stenophylla*).
Lemonade sumac, locally known as skunkbush	(*Rhus trilobata*).
Little buckthorn or Heaththorn	(*Microrhamnus ericoides*).
Mesquite	(*Prosopis sp.*).
Needle grass	(*Aristida sp.*).
Oaks	(*Quercus sp.*).
Parosela formosa.	
Parosela lanata.	
Paspalum bushii.	
Perezia nana.	
Plaintain, often called Indian-wheat	(*Plantago sp.*).
Poverty grass—Three-awn grasses	(*Aristida sp.*).
Red bud	(*Cercis occidentalis*).
Sagebrush	(*Artemesia filifolia*).
Saltgrass	(*Sporobolus airoides*).
Sandbur	(*Conchrus sp.*).
Shawnee haw.	
Shin oak	(*Quercus havardi*).
Side-oat grama	(*Bouteloua curtipendula*).
Snakeweed, locally known as tarweed, broom weed, and turpentine weed	(*Gutierrezia sp.*).
Sporobolus cryptandrus.	
Sporobolus giganteus.	
Tallow weed	(*Amblyolepis setigera*).
Texas grama	(*Bouteloua trifida*).
Texas jujube	(*Zizyphus obtusifolia*).
Three-awn grasses	(*Aristida sp.*).
Tobosa grass or coarse mesquite grass	(*Hilaria mutica*).
Wild China berry.	
Woolyfoot	(*Bouteloua eripodia*).
Yucca	(*Yucca glauca*).

In general, the grasses may be grouped in several rather distinct communities as follows: (1) Curly mesquite grass and buffalo grass, (2) needle grass and grama grass, (3) thin-cover phase of needle grass and grama grass, (4) bunch grass, (5) dunesand phase of bunch grass, (6) rough-and-stony-land phases of curly mesquite grass and needle grass, and (7) desert shrub vegetation.

Each group includes one or more grasses of similar appearance and characteristics, with approximately the same environmental requirements. These communities are not pure, however, for in each there are a few species of various other grasses or plants which belong to and predominate in other communities.

The following sketch map (fig. 62) shows the general location of these plant communities within the surveyed area.

Curly mesquite grass and buffalo grass community.—The curly mesquite grass and buffalo grass community includes principally buffalo grass (*Bulbilis dactyloides*) and some species of grama grass and mesquite grass. In some places the stand is almost entirely buffalo grass; in others it is composed, to a considerable extent, of mesquite grasses or grama grasses, or both. The grama grasses include *Bouteloua curtipendula*, or side-oat grama; *B. hirsuta*, or black grama; *B. gracilis*, *B. texana*, *B. barbata*, and *B. trifida*, or Texas grama; and *B. eriopoda*. Of these *B. gracilis*, *B. curtipendula*, and *B. hirsuta* are the most common in the curly mesquite grass and buffalo grass community.

Two mesquite grasses are found in this community—*Hilaria mutica*, or tobosa grass, a coarse-bunch mesquite grass, and *H. belangeri*, or curly mesquite. The latter is associated rather closely with the buffalo grass in all parts of the area. Locally, buffalo grass is referred to as mesquite grass, and *H. mutica*, a mesquite grass, is commonly called buffalo grass in the eastern part and tobosa grass in the western part. A few species of needle grass appear in the short-grass community in many places.

The curly mesquite grass and buffalo grass community, comprising mainly plants of shallow-rooting proclivities, grows principally on the heavy soils where much of the rain water, in dry seasons, penetrates only a few inches in the hard dry soil and is easily lost by evaporation. Here only such plants can thrive as are most resistant to drought, and these grasses have the power of lying dormant in dry seasons, and growing rapidly when the rains come. They are cured on the ground during the fall and winter, affording good grazing even after the grass is dead. They are the most nutritious grasses and the most highly prized by the stockmen.

The curly mesquite-grass and buffalo-grass community includes the principal vegetation on Amarillo clay loam, Abilene clay loam, Abilene silty clay loam, Miles clay, Miles clay loam, the rolling phase of Miles clay loam, Valera clay, Reagan silty clay loam, and Roscoe clay. On the flat dark soils such as Roscoe clay and Valera clay and especially of the brown (Abilene) soils and black (Roscoe) soils in depressions where surface water accumulates readily and is held until it is absorbed by the soil, *Hilaria mutica* grows densely in many places, almost to the exclusion of other plants. In such places grass locally known as wire grass (*Panicum obtusum*) also grows abundantly in the lower positions.

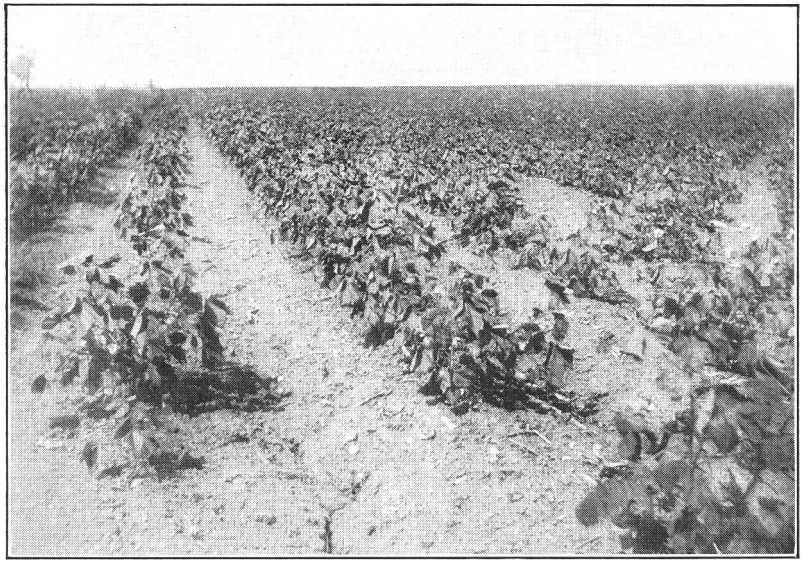

FIG. 1.—GOOD COTTON ON UNDIFFERENTIATED ABILENE AND VALERA CLAYS BEGINNING TO WILT AS THE RESULT OF A LONG DROUGHT

Note the cracks in the soil

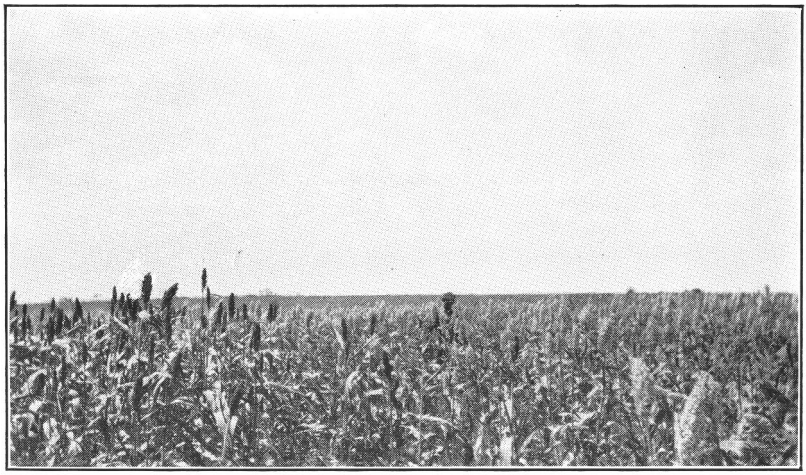

FIG. 2.—MILO AND SPUR FETERITA ON AMARILLO FINE SANDY LOAM, 5 MILES NORTHWEST OF COAHOMA, HOWARD COUNTY

FIG. 1.—SWEET POTATOES GROWN ON AMARILLO FINE SANDY LOAM WITHOUT IRRIGATION

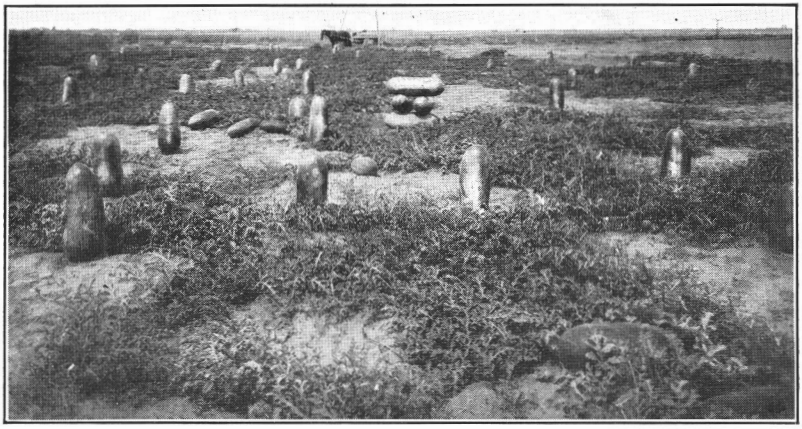

FIG. 2.—WATERMELONS GROWN ON AMARILLO FINE SANDY LOAM, NEAR MIDLAND

FIG. 3.—BEANS GROWN ON AMARILLO FINE SANDY LOAM, NEAR MIDLAND

As a rule, the short grasses cover the ground in a dense mat, but this is not true on Reagan silty clay loam, especially on the most westerly extension of it. Here the stand of grass is thin and much of

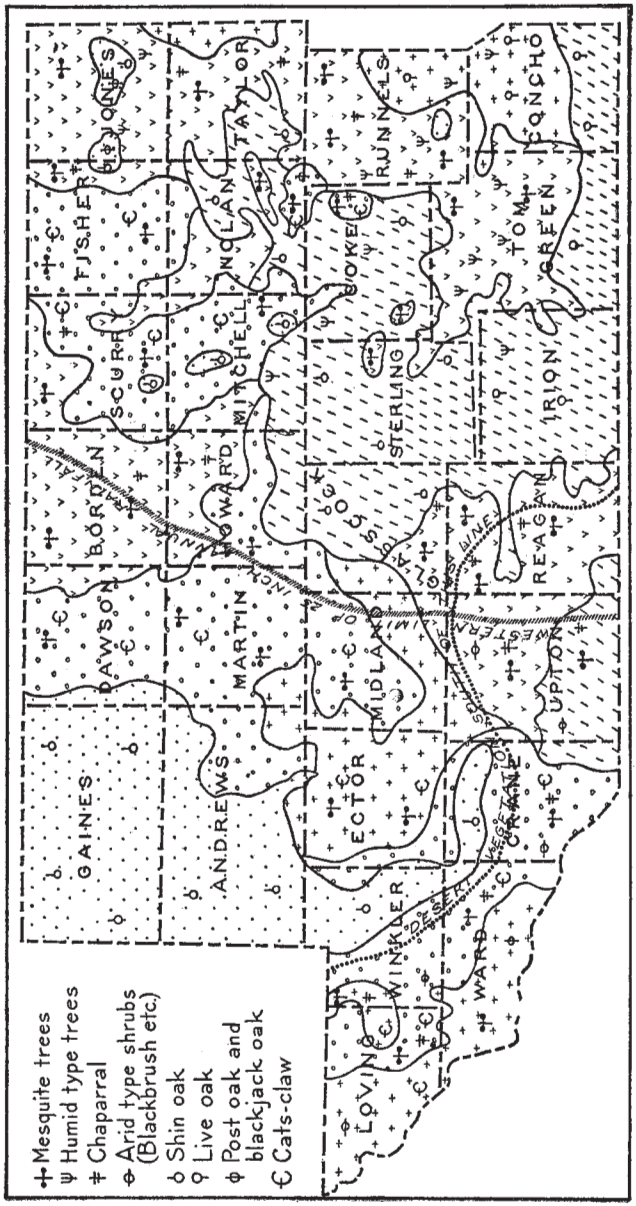

FIG. 62.—General distribution of shrubs and trees in the west-central Texas reconnaissance area

the ground is bare. This soil occurs in a rather dry section, is apparently richer in lime than most of the other short-grass soils, and supports a vegetation characteristic of arid soils. A very thin scattering

of small mesquite trees is associated with the short grasses, also some chaparral. Broomweed, or turpentine weed (*Gutierrezia* sp.), is abundant in many places in this plant community.

The area occupied by the curly mesquite grass and buffalo grass community abounds in small lake beds which are dry except in rainy seasons. When water stands in them a considerable growth of dwarf club-rush (*Eleocharis palustris*) appears. In these lake beds occur Randall clay, and in many places around the edges there is often a growth of blueweed (*Helianthus ciliaris*). Amarillo clay loam and Valera clay probably produce the purest short-grass growths. A rather persistent, though far from abundant, grass in the curly mesquite grass and buffalo grass community is *Triodia pilosa* on the heavy soils of the eastern part. Short grasses grow to some extent on rough broken lands, rough stony lands, and shallow soils, but they are mixed with other grasses, shrubs, and small trees.

Needle grass and grama grass community.—The needle grass and grama grass community includes needle and grama grasses in varying proportions, but in many places needle grasses are either the sole growth or the predominating growth. The needle grasses of the community include principally *Aristida longiseta*, *A. purpurea*, and *A. reverchoni*, and the gramas like those of the curly mesquite grass and buffalo grass community already mentioned.

This group of grasses is more abundant on the fine sandy loam soils; that is, soils having sandy or loamy topsoils with clay subsoils. The largest area of soil of this texture is Amarillo fine sandy loam, and it supports a heavy growth of needle grass (probably *Aristida longiseta* predominating) and several species of gramas. Where the soil is somewhat heavier ("tight sandy land") there is an admixture of more or less buffalo grass. Associated with the needle grass and grama grass community is a very scattered growth of small mesquite, chaparral, and some cat's-claw. On these soils the cat's-claw is a typical growth and gives rise to the local term "cat's-claw land." Cat-claw (*Acacia* sp.) is very abundant on some phases of these soils where the clay subsoil occurs unusually far below the topsoil of loamy fine sand. The community on Vernon very fine sandy loam includes considerable *Sporobolus cryptandrus*.

On Richfield and Amarillo soils *Bouteloua eriopoda* is a very abundant grass in this community. The needle grass and grama grass community occurs largely on soils where plants withstand droughty conditions somewhat better than do the curly mesquite and buffalo grasses. This is due to the loose, friable condition of the sandy surface soil which enables a ready collection and absorption of all rain water and to the heavy clay subsoils which act as good reservoirs for the soil water. Therefore the rather deep-rooted plants like the needle grasses do best on these soils. Soils favoring the growth of the needle grass and grama grass community are Amarillo fine sandy loam, Miles fine sandy loam, Miles fine sandy loam, rolling phase, Amarillo loamy fine sand, Richfield loamy fine sand, and Vernon very fine sandy loam. Vernon fine sandy loam somewhat resembles the other soils, and the grass community on it is about the same, with the addition of a thin forest of small blackjack and post oak on a shallow sandstone phase in the eastern part of the area.

Needle grass and grama grass community, thin-cover phase.—This phase of the needle grass and grama grass community occurs thinly distributed over some large areas, but covers only from 10 to 40 per cent of the surface. It comprises the usual grasses of this community associated with a scattering of small shrubs of various kinds, mainly mesquite brush or shrub, some chaparral, and a little cat's-claw.

This phase of the community occurs on shallow soils with smooth surfaces, where erosion has removed the topsoil but has not as yet caused severe dissection. The thin layer of soil material which rests on caliche and hard limestone comprises the following soils: Shallow phase of Amarillo loam, Reeves gravelly loam, shallow phase of Abilene clay loam, Valera clay, and Ector gravelly loam. Where the shallow surface soil is heavy, as in the shallow phase of Abilene clay loam, and in Valera clay, a small quantity of short buffalo grass and curly mesquite grass also appears. On Reeves gravelly loam some drought-resistant vegetation also is present. During the early spring of this season (1922) considerable rain caused a fair growth of grasses of this thin-cover phase; but in a very dry season the grass cover is usually very scant, as these soils are droughty on account of the shallow surface soil and the hard or semihard parent material just below the surface.

Bunch-grass community.—The bunch-grass community in this area might perhaps be better termed the shin oak, bunch grass, and artemisia community, as these three plant groups are closely associated. The most abundant and prominent grass is blue stem, or "broom sedge" (*Andropogon scoparius*). However, the most abundant growth in the community is shin oak (*Quercus havardii*) which grows very thickly and from 1 to 2 feet tall. Bunch grass (Andropogon) shows above or among the shin oak, giving the landscape a reddish sheen. Sagebrush or sand sage (*Artemisia filifolia*) occurs prominently but not uniformly in this community, being very scattered and thin in some places and in others so thick as to exclude other vegetation. Broomweed or turpentine weed (*Gutierrezia* sp.) which occurs rather universally, is not so prominent as the first-mentioned plants. Some yucca (*Yucca glauca*) and a small quantity of cat-claw are also included.

The bunchgrass community is confined to the loose fine sandy soils which have clay subsoils generally at depths varying from 2 to 4 feet. These soils collect and absorb practically all the rain water that falls, and the clay below holds a large supply of water which is retained because of the protection afforded by the deep surface covering of fine sand. The principal soil on which this vegetation grows is Amarillo fine sandy loam, light phase; Miles fine sand; Miles fine sand, shallow phase; and Miles fine sandy loam also have this characteristic bunch-grass community, and occur inextensively in the eastern part of the area.

The bunchgrass community on shallow Miles fine sand, and on Miles fine sandy loam is associated with small blackjack oak and post oak. This latter growth is perhaps due to the somewhat more abundant rainfall on these soils in the eastern part of the area than in the northwestern part where the altitude is about 1,000 feet higher.

As a rule, in the bunchgrass community the abundance or predominance of certain species depends on the depth of the sand over the clay. Thus, on ridges or mounds where the sand is deepest, shin oak from 6 to 8 feet high constitutes almost the sole vegetation; on deeper sand on rather flat or depressed land *Artemisia filifolia* predominates; and on smooth areas where clay lies from 18 to 36 inches below the surface, very small shin oak and bluestem predominate, combined with a small quantity of short grasses.

Bunchgrass community, dunesand phase.—This phase is similar to the typical bunchgrass community in many respects, but the plant cover is somewhat thinner and the grasses are very scant and scattered, growing principally in depressions or old "blow-outs" and on interdune flats. The dunes, many of which consist of bare, drifting fine sand, have mostly a growth of shin oak and coarse plants. The grasses of the phase, besides bluestem, comprise rather large but not abundant grasses of which *Sporobolus giganteus* is a representative. Yucca and Artemisia are also abundant. A thin growth of many coarse plants occurs in the low places and on the dunes. Of these, *Heliotropium convolvulaceum*, *Parosela lanata*, *Paspalum bushii*, and *P. pubescens muhlenbergii* are the most abundant. Dunesand is a thin, loose soil of no great productivity, but it catches and holds all rain water in the depressions between the dunes, and this sinks to a considerable depth. Even in very dry seasons vegetation is somewhat abundant and the land is utilized for grazing.

Mixed curly mesquite grass and needle grass community, rough stony land phase.—There are large areas of eroded, stony lands which are more or less rough and broken, and physiographically unsuited to farming. The soil is generally very thin and is entirely absent in some places. On these lands the vegetation is a mixture of curly mesquite, needle, and grama grasses, but there is no grass on excessively stony areas. A fairly good shrub and small tree growth occurs, consisting of occasional small mesquite trees in some places, cedar (juniper) in some places, and shin oak and live oak in others. Cat-claw and chaparral, and numerous shrubs grow promiscuously in this community. Redbud (*Cercis occidentalis*) is also found. The soils here are dark and heavy. Exposures of limestone and chalky parent material give a light color in many spots, and there are stony fragments on the surface. These lands are classified mainly as rough broken land, rough stony land, Valera stony clay, and Reagan gravelly silty clay loam. The latter soil also has considerable vegetation of the arid type. Grasses and many other plants afford good pasturage for cattle, sheep, and goats, and range conditions are good in years of adequate rainfall, but poor in dry seasons.

Desert-shrub vegetation.—In addition to the general plant communities, an arid-land type of vegetation appears in the southwestern part of the region. The shrubs, which are the most conspicuous vegetation of the community, consist principally of black brush (*Flourensia cernua*), creosote bush (*Covillea tridentata*), little buckthorn (*Microrhamnus ericoides*), and a saltbush (*Atriplex canescens*). The mesquite tree has only a bush development here. The principal weeds are snakeweed (*Gutierrezia* sp.) which attains only a low growth, croton weed (*Croton texensis*), and *Perezia nana*, a small persistent plant. The grasses are the same as those described in the

mesquite-grass community on Reagan silty clay loam, and in the needle-and-grama grass community on Reeves gravelly loam. In addition to small quantities of these grasses some burro grass (*Scleropogon brevifolius*) and salt grass (*Sporobolus airoides*) are present. Cat's-claw and chaparral also are abundant, as well as Brigham tea, on all soils on which the arid type of vegetation occurs.

Where this vegetation occurs, just east of Pecos River, the growth seems to be a transition from the arid into the semiarid types of vegetation. The shrub growth is several feet high and may be thinly distributed or very thick. Grass is very scant in most places and usually short even in rainy seasons. The vegetation of this belt indicates very dry conditions. Here the rainfall is scant and the soils for the most part have a low moisture-holding capacity, as Reeves gravelly loam and Reeves chalk. Little buckthorn is seen on some of the stony and chalky slopes, where it is associated with a small blue-flowered shrub, *Parosela formosa.*

In this area the relationship of certain native plants to certain soils seems to be rather definite. A preponderance of short grasses, such as curly mesquite and buffalo grass, indicates dark heavy soils, rather deep and of good agricultural value, but on which crops are more easily injured in dry years than on soils thickly covered by needle and grama grasses. These short native grasses indicate soils suitable for small grains, cotton, sorghum, and forage crops.

A thick cover of grasses of the needle-and-grama grass community seems to indicate soils of good moisture-holding power suited to a variety of crops, such as cotton and grain sorghums, but more especially suited to vegetables and fruits. Where the grass growth is thin and short and the associated shrubs comparatively small, the soils are shallow and of little agricultural value.

The bunch-grass community indicates in this area shallow, light, sandy soils underlain by clay at a depth of 2 or 3 feet. The soils have good water-holding power and drought resistance, but are so light in texture as to allow considerable blowing during high winds. They are suitable for melons, fruits, vegetables, forage crops, and sorghum. The bunch grasses in certain places give way largely to shin oak and grow very thin, both of which conditions indicate deep drifting sand or shallow soil of very little agricultural value.

The native grasses of the area constitute a considerable natural resource. They have made possible the extensive development of the great ranching industry, as they have long been the principal feed for livestock. The buffalo, curly mesquite, and grama grasses are considered the most nutritious. The needle and tobosa grasses are good feed when young, but become unpalatable when mature and then are not eaten readily by livestock. Needle grass appears earliest in spring in many places and affords valuable feed until the more nutritious grasses become available. Heavy pasturing on the range where short grass and grama and needle grasses grow seems to increase the proportion of needle grass, thus reducing to a certain degree the quality of the pasture.

SOILS

The area covered by the west-central Texas soil reconnaissance is a large one and extends from east to west a distance of 250 miles

and from north to south about 130 miles. The climatic conditions vary greatly within the area, the mean rainfall ranging from about 25 inches near the eastern boundary to less than 15 inches in the extreme western part.

The soils in the eastern part of the area differ from those in the western part, and those in the north vary somewhat from those in the south. The latter is more a geological variation than a soil variation. The dark-colored soils are found in the eastern part of the area and the lightest-colored soils in the western part. Likewise the heaviest soils, generally speaking, occur in the eastern part and the lightest in the western part of the area; that is, a larger proportion in square miles of the soils of the eastern part of the area are heavier in texture than those in the western part. The Abilene and Valera soils, extensive soils of the eastern part, are darkest; the Miles soils of the central portion are intermediate in color and texture, and the Amarillo and Reeves soils, predominant in the western part, are still lighter textured and lighter colored.

Darker-colored Upland Soils

The Abilene soils occur in a roughly northeast-southwest belt, extending from southwest of San Angelo to the northeastern part of the area, though north of Tuscola areas are scattered rather than in a solid belt.

The Valera soils in this area are developed mainly in a broad curving belt extending southward from Big Spring to the southern boundary and thence eastward to the southeastern corner of the area. A smaller area lies a few miles south of Sweetwater and a still smaller one east of Ballinger. The Valera soils occur on top of Edwards Plateau, the main belt occupying the northern end of the unbroken plateau. Both this belt and the isolated areas are from 100 feet or less to several hundred feet above the smooth, rolling lowland where the Abilene soils are found.

Abilene and Valera soils are alike in general characteristics. Both are dark in color and have developed in areas having surfaces uneven enough to provide fair drainage under the prevailing climatic conditions. Both soils therefore have undergone a normal development, and represent the result of the unrestricted action of the soil-forming forces of the region. Both are characterized by similar layers which constitute a soil profile. In this region the profile that is common to these two soils may be described from the surface down, as follows: A dark-colored surface soil, a lighter-colored lower layer, both of which are usually free from lime carbonate or readily soluble salts, and a third layer, either gray, white, cream, or pinkish-gray in color containing a high percentage of lime carbonate. The third layer occurs at depths varying from 20 to 50 inches, and may be more than a foot thick. The three layers constitute the true soil, and the material below, or the substratum, represents the parent material.

The difference between the Abilene and Valera soils is to be found mainly in the character of the substratum material. The Abilene soils are underlain by unconsolidated material which may consist of reddish heavy clays, shales, sandy clays, soft sandstones or grayish limestone gravel. The Valera soils, on the other hand, are underlain by solid limestone or by disintegrated residual products of limestone

or limy shales. The Valera soils are shallow in many areas, the limestone occurring less than 3 feet below the surface. These shallow areas have not been mapped separately, though occurrences of Valera stony clay represent, in general, areas of shallow soils, whereas areas of Valera clay represent deeper soils.

Light-colored Upland Soils

In the northwestern part of the reconnaissance region, Amarillo soils occur extensively in an area more than 100 miles long from east to west and more than 60 miles wide from north to south. These soils occur entirely on the High Plains and in areas having smooth surfaces. They are predominantly more sandy than the soils of the eastern part of the area, consisting mainly of fine sandy loams, though a large area in the northwestern part of the region is made up of a covering of sand over heavier material. This is more nearly a sandy loam than a sand, however, since the depth to clay or sandy clay is less than 2 feet. There are also places where the sand has blown into ridges, so that the depth to clay is much greater.

The Amarillo soils nearer the center of the region, especially in the vicinity of Big Spring, are somewhat darker than the corresponding textural types of the Miles soils occurring in Borden County. They are also much less red than the Miles soils, though below a depth of 1 foot, the red color is apparent; and where the lime-bearing layer occurs more than 2 feet below the surface the lower part of the soil above the lime layer is definitely reddish. The surface soil is dark brown, the brown doubtless developed from the red color below, and being more marked than in the Abilene soils.

In the western part of the area where the light phase of Amarillo fine sandy loam occurs, both color and texture of the soil are lighter than in the Amarillo fine sandy loam in Dawson, Martin, Howard, and Midland Counties. The lighter color is due in part to the decreased rainfall and the resulting decrease in the growth of grass, and in part to the lighter texture, which also diminishes the luxuriance and density of the grass cover to some extent, and consequently reduces the supply of organic matter in the soil.

In the extreme western part of the area mapped, the lime carbonate zone in the soil is encountered nearer the surface in Amarillo fine sandy loam than in the same type of soil in the eastern part of Dawson County, and considerably nearer the surface than in the Abilene soils in the eastern part of the region. The depth to the lime carbonate zone would be still greater in the eastern part if there were any areas of Abilene fine sandy loam in that part, because it is generally true that when other factors are equal, the depth to the layer of accumulated lime is greater beneath the surface of a light-textured material than beneath a heavy-textured topsoil. In New Mexico, a few miles from the western boundary of the area, the lime zone has become indurated to stonelike hardness and occurs within a foot of the surface in many large areas. On the Texas side of the New Mexico-Texas line, such areas are small. The sand in this part of the area seems to be wind blown, and where it is deep the soil features just described are buried.

Amarillo loamy fine sand consists of wind-blown material that has lain in place long enough to take on a slightly dark color and which is reddish beneath the surface. It lies in a region where the rainfall is much lighter than in the vicinity of Big Spring where Amarillo fine sandy loam is found. It is also lighter in color. The moisture that falls on sand is much more effective than that on fine sandy loam, since it is more completely absorbed by the soil. This being the case, a single characteristic or a number of characteristics will develop on a sand under conditions of much lighter rainfall than that required by heavier-textured material. There may be a question as to the wisdom of identifying the same soil in a region having as wide difference in rainfall as that between Big Spring (about 20 inches) and Kermit (about 15 inches). It is undoubtedly true that the extremes of conditions here reach the widest limit, and even with the same materials the same types of soil would not develop in the two localities, especially since in addition to a higher rainfall, Big Spring has a higher temperature owing to its lower elevation.

Reeves soils are found in a belt parallel to Pecos River. They have developed in a region of high temperature and low rainfall and from materials that are comparatively heavy in texture. The moisture supply has been too small to promote the growth of grass and the natural vegetation consists of thorny and thornless brush. The soils vary in color from light brown to gray and are underlain at shallow depths by a zone of concentrated lime carbonate or lime sulphate (gypsum) or a mixture of both.

Intermediate Soils

The soils intermediate between the eastern and western parts of the area are those of the Miles series, which occur in a large area in the northern part of the region mapped, the main body lying in Borden, Scurry, and Mitchell Counties, and a large area in northern Taylor County and in Jones County. Miles soils are lighter in color and also somewhat redder than the soils of the Abilene series. This lighter color is largely due to two factors; (1) the incorporation of less organic matter in the soil, and (2) less absorption of rain water on the more rolling surfaces. Miles soils are somewhat lighter in texture than Abilene soils, especially in the western part of the main area in which they occur, and consequently accumulate organic matter, other things being equal, at a slower rate than the heavier Abilene soils, and also hold it less tenaciously. Miles soils are predominantly rolling-land soils. Were the areas on which they are found as smooth as those on which the associated Abilene soils are found soils of the Miles series would have developed exactly as Abilene soils. The more rolling surface relief causes a greater loss of the rain water through run-off than takes place on the smoother areas of Abilene soils. These factors constitute the difference between Miles and Abilene soils in Jones and Taylor Counties. They have both been developed from the same kind of material and under like conditions, except for the more rolling surface of the land.

The extensive area of Miles soil in Borden, Scurry, and Mitchell Counties is so rolling that most of the soils are mapped as a rolling

phase. The soils are necessarily of a lighter color which is enhanced by the lighter texture of the soil material and also by a third factor embodied in a somewhat lighter rainfall in this part of the area than in the eastern part. This reduced soil moisture also effects a reduction of the quantity of organic matter.

The somewhat lighter color of Miles clay loam in the western part of Borden County than that in Jones and Taylor Counties is due to the lower rainfall and the more rolling topography. That of Miles fine sandy loam is due to all three of the factors mentioned. The rolling topography is caused by active erosion of the headwaters of Colorado River. The original cap of the high plains has, in very recent geological times, been removed in this locality and the rivers have not yet reduced this particular area to the smooth country characteristic of Jones and northern Taylor Counties, in which the processes of erosion have reached a much more advanced stage and produced an older and smoother topography.

Miles soils are also redder than Abilene soils, because of (1) the lower percentage of organic matter which, in the Abilene soils, tends to overlie the reddish color of the soil particles; (2) the smaller quantity of soil moisture and consequent more thorough oxidation of the iron in the soil material throughout the soil; and (3) the character and reddish color of the parent rock. Abilene soils have developed from essentially the same parent material, but the red color is hidden and the more thorough weathering has tended to produce a soil color that is less bright red than the color of the parent rock.

Other Soils

Roscoe clay is a soil occurring on flat areas and its characteristics are in part the product of a higher moisture content than that of Abilene soils, which are nearest the Roscoe soils in character. They are darker in color than the Abilene soils, and the dark-colored layer may be as much as 2 feet thick, and the lighter-colored layer beneath is thinner than in the Abilene soils and less reddish or brownish in color. The layer of accumulated lime carbonate is present and well developed, but is gray rather than pinkish in color. These soils are found on flat areas in close association with Abilene soils, and are best developed in the vicinity of Roscoe, west of Sweetwater. These soils have not been previously mapped.

In the south-central part of the region surveyed there is a large area of soils, mapped as members of the Reagan series, made up of Reagan silty clay loam and Reagan gravelly silty clay loam. These soils occur in a region where the grass cover is light and the natural vegetation consists largely of thorny brush. They are more like desert soils in most, if not all, of their characteristics than the subhumid soils of the northern and eastern parts of this area. They are calcareous from the surface downward, are light in color, ranging from grayish brown to reddish brown, and break up into clods like many imperfectly developed dry-land soils. Their high lime-carbonate content strongly indicates that these soils are not yet mature in their development, though the presence of a zone of somewhat indurated lime indicates that their stage of development is not one of extreme youth. They occur in a belt where the surface soil

at maturity has been deprived of such lime carbonate as may have been present in the parent or source material, and the fact that they still have a high content of lime carbonate may indicate their immature condition.

Their less mature stage of development than in the Amarillo soils, which occur in the same belt and are affected by essentially the same environment, is due in part to their heavy texture, inasmuch as a heavy soil always develops at a slower rate than a lighter soil.

West of the region where Reagan soils are found, there is an area in which a wide strip of dunesand, two rather wide strips of Amarillo loamy fine sand, and in the extreme southwestern part a strip of Reeves soils along the Pecos River, are in close association. The dunesand is stationary in most places and is covered with a fair growth of grass, mainly Andropogon.

A group of soils in Ector County, in an area a few square miles in extent, were differentiated and mapped as Ector soils. They differ slightly from the Reeves soils.

Types of Soil

Detailed descriptions of each of the soil types in the area surveyed will be found in the subsequent pages of this report. The following table shows the names of the soil types mapped in this survey and the extent of each in the region mapped.

Types of soil and their extent in reconnaissance area of west-central Texas

Type of soil	Acres	Per cent
Amarillo loamy fine sand	709, 632	4. 1
Amarillo fine sandy loam	1, 744, 128	17. 8
Light phase	1, 308, 672	
Amarillo loam, shallow phase	261, 136	1. 5
Amarillo clay loam	375, 552	2. 2
Richfield loamy fine sand	311, 040	1. 8
Richfield silty clay loam	55, 296	. 3
Ector gravelly loam	430, 848	2. 5
Randall clay	6, 912	. 1
Abilene clay loam	799, 488	8. 1
Shallow phase	573, 696	
Abilene silty clay loam	1, 320, 192	7. 7
Miles fine sand	25, 344	. 5
Shallow phase	62, 208	
Miles very fine sandy loam	34, 560	. 2
Miles fine sandy loam	165, 888	5. 4
Rolling phase	760, 320	
Miles clay loam	647, 424	7. 5
Rolling phase	638, 208	
Miles clay	32, 256	. 2
Roscoe clay	69, 120	. 4
Vernon very fine sandy loam	216, 576	1. 2
Vernon fine sandy loam	25, 344	. 1
Vernon clay loam	170, 496	1. 0
Vernon clay	135, 936	. 8
Valera silty clay loam	99, 072	. 6
Valera stony clay	1, 797, 120	10. 5
Valera clay	495, 360	2. 9
Abilene and Valera clays (undifferentiated)	129, 024	. 8
Reeves fine sandy loam	258, 048	1. 5
Reeves gravelly loam	532, 224	3. 1
Reeves chalk	55, 296	. 3
Reagan gravelly silty clay loam	364, 032	2. 1
Reagan silty clay loam	1, 103, 616	6. 5
Light-colored phase	6, 912	
Miller fine and very fine sandy loams and silt loam (undifferentiated)	39, 168	. 2
Miller silty clay loam	48, 384	. 3
Yahola soils (undifferentiated)	39, 168	. 2
Frio silty clay loam	78, 336	. 5
Spur sandy soils (undifferentiated)	25, 344	. 1
Spur heavy soils (undifferentiated)	66, 816	. 4
Arno clay	55, 296	. 3
Pecos clay	25, 344	. 1
Dunesand	539, 136	3. 2
Rough stony land	440, 064	2. 6
Rough broken land	73, 728	. 4
Total	17, 141, 760	

AMARILLO LOAMY FINE SAND

The surface soil of Amarillo loamy fine sand consists of brownish-red loamy fine sand from 8 to 12 inches deep, which in an air-dry condition has a distinct grayish-red color. The subsoil to a depth of about 36 inches is also loamy fine sand, but more reddish. On

drying, the virgin topsoil and subsoil both become rather hard, but the hard mass may be easily broken. Caliche lies several feet below the surface and consists of soft white chalky material, which on exposure to air becomes somewhat hard. Carbonate of lime, as indicated by test with hydrochloric acid, is not everywhere present.

Amarillo loamy fine sand occurs in rather large bodies in the southwestern part of the area in Loving, Winkler, Ward, Crane, and Ector Counties. It extends north and south in broad belts near and sometimes adjoining dunesand areas, and is also closely associated with the sandy and gravelly soils of the Reeves series.

In the extreme southwest Amarillo loamy fine sand consists of wind-blown material that has remained in place long enough to become slightly dark in color and reddish beneath the surface. It occurs in a region where the rainfall is much lighter than at Big Spring and the soil is lighter in color.

Amarillo loamy fine sand occurs on a nearly level or very gently undulating plain, with a sufficient growth of small trees and shrubs to give a semiprairie effect. The surface drainage as well as underdrainage is good.

The native vegetation consists of a scattered growth of small mesquite trees with patches of yucca or bear grass. The grass on this soil is fairly luxuriant and consists principally of tall and short needle grass, with here and there a considerable quantity of grama grass (*Bouteloua eriopoda*).

This soil is not cultivated and is utilized only for the good grazing it affords. It supports from 2 to 25 head of cattle to the square mile. Good grazing and a plentiful supply of good water, which can be obtained from wells ranging in depth from 30 to 60 feet, make this land suitable for ranching. This soil is naturally fairly productive and, were the rainfall sufficient, would produce fair yields of sorghum, cotton, fruits, and vegetables.

The current value of this land varies from $5 to $12 an acre in large tracts, and the yearly grazing rental from 10 to 15 cents an acre.

AMARILLO FINE SANDY LOAM

The topsoil of Amarillo fine sandy loam is reddish-brown fine sandy loam, from 8 to 12 inches deep. Below that, to depths varying from 18 to 24 inches, the red or chocolate-red subsoil grades from fine sandy loam to sandy clay, becoming gradually heavier with depth; and below 24 inches it is rather crumbly red sandy clay. In places the lower subsoil is slightly lighter red in color. Where dry and uncultivated the topsoil and subsoil become very hard, but break up readily into small clods; where moist, or in cultivated fields, the topsoil is very friable, and the subsoil crumbly. Where caliche or lime beds occur from 3 to 5 feet below the surface the topsoil and subsoil are not calcareous, but where they occur within 24 inches of the surface, the topsoil and subsoil are both somewhat calcareous.

Amarillo fine sandy loam is very extensively distributed and occurs as very large bodies on Llano Estacado, or the High Plains, in the greater part of Dawson, Martin, and Midland Counties, and also in Andrews, Howard, and Ector Counties. Included in mapped areas of this soil are small areas of other soils that could not be

shown separately under reconnaissance methods. These consist mainly of a light-phase Amarillo fine sandy loam, Amarillo loam, shallow Amarillo loam, Amarillo clay loam, and some Richfield loamy fine sand.

Areas of Amarillo fine sandy loam vary from almost level to gently rolling plains. In a few places, as in the southern parts of Howard and Midland Counties, the rolling plain is rather pronounced. The greater part is more than 2,000 feet above sea level. Drainage is good. A number of small draws carry off some of the surface water, though most of the rainfall is readily absorbed by the topsoil and held in storage in the heavy subsoil. Much of the run-off goes into the many small playas, which range in size from 10 to 40 acres, and which abound in areas of this soil. These lake beds consist of Randall clay.

A scattered growth of small mesquite trees and some chaparral growth accompanies the characteristic and abundant cat-claw, the heaviest growth of which occurs in southeast Andrews County and in Martin County. Many inhabitants refer to this soil as cat's-claw land. The most prominent of the numerous weeds is the turpentine weed, and bear grass (Yucca) is present in small quantities. In the southern counties the surface is covered by a heavy growth of good grasses, which includes needle grass, associated with grama grass. On the northern bodies of this soil, as in Dawson County, needle grass is not so abundant, the grama and buffalo grasses predominating.

Amarillo fine sandy loam is utilized principally for ranching and it affords the best grazing land of the large cattle ranches. In seasons when grass is abundant, the land will carry from 50 to 75 head of cattle to the section for a long period, but it is estimated that over a period of years the average number of cattle grazed would be about 35 head to the section. Probably not more than 5 per cent of the land is in cultivation, the main areas utilized for farming being around Midland, Big Spring, Stanton, and Lamesa. This soil is suitable for farming, as it stands dry conditions very well, especially where cultivated thoroughly. It does not blow so badly as the lighter-textured soils, it is rather productive, and is suited to a variety of farm crops.

The main crops grown are grain sorghums, chiefly milo, which yields from 20 to 40 bushels an acre; cotton, yielding from one-half to three-fourths bale an acre; and sorgo for roughage, yielding from 4 to 6 tons an acre. Small fields of corn, when moisture conditions are favorable, produce from 25 to 35 bushels an acre. Some Sudan grass is grown and yields are good. (Pl. LXVI, fig. 2.) This soil is well suited to cotton, and much of the land is being broken by cotton farmers and doubtless much more will be utilized for farming within the next few years.

The soil is too light for the maximum production of small grains, though these could be profitably grown for winter grazing in years when the moisture conditions are favorable. It is well suited to vegetables, fruits, and berries, and many farms and ranches have small home gardens irrigated by water pumped from wells by windmills. Peaches, plums, berries, and grapes do especially well.

Good yields of alfalfa and other farm crops have been obtained by irrigation near Midland, the water being pumped by engines from

wells from 100 to 150 feet deep. The water is very good and it is plentiful. Only a few places have been irrigated for the production of commercial crops like cotton and alfalfa, and although the results with these crops were good the economic advantage of producing the general farm crops under irrigation has not as yet been proved.

Farms on this soil range in size from 160 to 640 acres, and ranches range from 4 to 50 sections. The current value of land ranges from $15 to $25 an acre for virgin land, and in good localities near railroads and towns improved farms sell for $50 or more an acre.

The United States Department of Agriculture maintains a dry-land experiment station on this soil at Big Spring where valuable experiments are carried on for the benefit of the agricultural interests of the region. Plate LXIV, Figure 2, shows a field of grain sorghum on Amarillo fine sandy loam in Howard County.

Amarillo fine sandy loam, light phase.—When dry, the surface soil of the light phase of Amarillo fine sandy loam consists of a layer 2 or 3 inches thick, of light-pink, loose, fine sand, underlain by fine sand that is deeper pink in color, moderately hard, and cloddy. At a depth varying from 8 to 10 inches, light chocolate-red fine sand appears which also is moderately hard and breaks up into small clods that withstand a stiff blow before crumbling. At a depth of about 14 inches light chocolate-red, very hard sandy clay subsoil is reached. The color grades with depth into lighter red, and at a depth of 3 feet yellowish-red material occurs in places. In many places the color does not change much and usually the structure of the sandy clay subsoil also changes very little until the whitish caliche makes its appearance, where the subsoil is somewhat more friable. Generally caliche does not occur within a depth of 3 feet, although there are occasional shallow patches where the pure-white caliche occurs at depths between 1 and 3 feet. (Pl. LXVII, fig. 1.) The caliche in these areas of shallow soil is generally much harder than that beneath the deeper soils. Pure caliche is ordinarily present in soils of this phase at depths ranging from about 3½ to 6 feet. This is characteristically soft and may be almost pure white or faintly pinkish. Above the white caliche the material is too low in lime to show any effervescence with hydrochloric acid.

In places the surface soil is reddish brown, owing to the accumulation of vegetable matter. In other areas, especially where the sand has accumulated by blowing, the depth to sandy clay varies from 20 to 30 inches.

In dry seasons like the summer of 1922, the moisture in the virgin soil becomes so low in late summer and fall that no trace of dampness can be detected to a depth of about 30 inches. After a three-month drought, a faint trace of moisture was noticeable in cultivated fields at a depth of about 12 inches, which had the effect of maintaining the friability of the surface soil. This soil is very retentive of moisture in average seasons, many farmers claiming that it holds so much moisture that cotton is inclined to mature too slowly in some years. It seems that the stiff sandy clay subsoil is slightly impervious to water, as water stands in the low places where the sand has been blown out for considerably long periods after rains. When wet, the subsoil is much more friable and can be penetrated readily with the soil auger, whereas boring is almost impossible when the

subsoil is dry. Land of this kind is locally styled "loose sandy soil," "shinnery land," and "shinnery sand," and the subsoil is called a "pan" or "claypan."

A very large body of this soil covers the greater part of Gaines County and at least half of Andrews County. A fairly large body is in the northwestern part of Dawson County, and also a few isolated areas. Areas of this soil extend beyond the limits of this survey westward into New Mexico and northward for many miles.

As mapped, Amarillo fine sandy loam, light phase, includes small areas of Amarillo fine sandy loam, Richfield loamy fine sand, Randall clay, Amarillo fine sand, and Brackett gravelly loam, too limited in extent to show on a map of the scale used in reconnaissance surveys. These areas, although rather unimportant, have some local effect on individual farms, and crop yields vary somewhat.

This land is flat or very gently rolling. A number of small lake beds form slight depressions which contain water only during rainy seasons. Shallow stream channels, locally called draws, give adequate drainage, but these are dry except immediately following rains. Although some water stands in depressions for some time after rains, a very large quantity is absorbed by the light sandy soil and passes quickly down into the sandy clay subsoil, where it is held in storage for growing plants. The subsurface drainage is good, as the clay is not so compact as to prevent ready percolation.

Small lake beds, usually less than 50 acres in extent and from 10 to 20 feet below the general surface, occur in areas of this soil; also several deep-bedded lakes which cover several sections of land. In the small lake-bed areas the soil is Randall clay. The larger lakes, on drying, leave their beds covered with salt incrustations containing principally sodium chloride and sulphates of lime, magnesia, and soda, and in places a small quantity of potash salts.[8] The largest of these lakes are Cedar Lake in northeastern Gaines County and Shafter Lake in central Andrews County. On drying, the latter leaves a thin crust of salts, largely sodium chloride, which is collected by ranchers for their livestock.

Good water is plentiful in areas of light-phase Amarillo fine sandy loam, obtained from wells usually ranging from 60 to 100 feet deep. However, in a strip of country in southwestern Andrews County it is necessary to bore to a depth of 700 or 750 feet for an adequate supply of water, and even then the water contains a very noticeable quantity of salts. As a rule the water supply is ample for all domestic and farm needs and in addition is sufficient to irrigate small areas of land in gardens and orchards.

The native vegetation on Amarillo fine sandy loam, light phase, consists of coarse grasses, weeds, and low shrubs, the most prominent growth being shin oak, which grows very thickly in most places and ranges in height from 6 inches to 3 feet. Here and there a few small mesquite trees are found, usually where the sandy surface soil is shallow. The grasses are principally little bluestem (*Andropogon scoparius*) and needle (Aristida sp.), with fairly dense patches of turpentine weed (Gutierrzia sp.) and sage brush (*Artemisia filifolia*) where the surface soil is deep, and bear grass, or yucca, in abundance in fields that have been cultivated and later abandoned.

[8] Analysis made by G. S. Fraps, State chemist.

Most of this land is utilized for ranching, for which it is probably most suitable. The tracts range in size from several hundred to several thousand acres, and some ranches, which consist almost entirely of this kind of land, comprise from 30 to 50 sections. This soil supports a fair growth of grass even in the driest seasons; and although not so nutritious as the buffalo and grama grasses on heavier soils, the range supports from 15 to 25 head of cattle to the section. In certain places, as in northern Gaines County, some cattle lose their young through premature birth, so that for this reason this section is sometimes called the "slink country."

Some ranchers cultivate small areas of this soil for their winter supply of cattle feed, which is almost entirely sorghum and sorgo. Probably not more than 1 per cent of this land is tilled. Within the last few years a number of farms have been operated and more land is brought under cultivation each year, especially in the northern part of Gaines County near the railroad.

The surface soil blows and drifts badly in the strong spring winds and at times fine sand covers the young plants, necessitating replanting of crops several times before a good stand is obtained. Crops are usually planted in April and early May, but they have a fair chance when planted as late as July.

The crops grown are grain sorghum, sorgo, corn, cotton, and some Sudan grass. Yields of sorghum range from 20 to 40 bushels an acre; corn, which is grown rather extensively on this soil, from 20 to 30 bushels in good seasons; cotton, about one-half bale in favorable seasons; and sorgo from 2 to 4 tons of cured forage. This soil should produce good yields of broomcorn.

Light-phase Amarillo fine sandy loam is considered a fairly good drought-resistant soil, and crop yields are fair even in very dry seasons, provided there is a moderate supply of moisture in the subsoil.

Cotton is the main cash crop, but corn is sold and shipped from some farms which are located near the railroad. Grain sorghums are usually fed on the farm, and if there is a surplus, it is either sold locally to other farmers or ranchers or it is threshed and the grain is shipped.

This kind of land is well suited to fruits and vegetables and many farms have small orchards or a few fruit trees, and gardens. One 60-acre orchard on this soil in Gaines County has produced a good crop of peaches, plums, apples, and pears every year since it began to bear nine years ago, although late frosts and freezes ordinarily destroy the fruit crop approximately two years out of five.

Grapes grow especially well, as do vegetables and berries, in small home gardens. Where the land is irrigated excellent yields are obtained in dry weather, although in many seasons the rainfall is adequate for all the regional crops without irrigation.

The current value of this land ranges from $5 to $24 an acre, depending on location and distance to railroads.

AMARILLO LOAM, SHALLOW PHASE

Amarillo loam, shallow phase, consists of loam or fine sandy loam usually reddish brown in color, from 2 to 14 inches deep. This material rests on hardened chalk or caliche which comes to the surface in places. Included in mapped areas of this soil are small gravelly

areas of extremely shallow Amarillo soil from which the reddish material has been removed by water or wind erosion.

The land is very gently rolling or undulating and has good surface and subsurface drainage.

In years of moderate rainfall the native vegetation consists of rather heavy grass. Some small mesquite trees are scattered over the land as well as chaparral and cat's-claw. There is much needle grass, grama, *Trioda pilosa*, and a scattering growth of turpentine and other weeds.

The land is utilized exclusively for grazing and is all included in cattle ranches. In good seasons it will carry from 30 to 40 head of cattle to the section. The soil is ordinarily too shallow for farming. On a few small areas where the soil is deeper yields of sorghum and sorgo would be fair with adequate rainfall or irrigation. A plentiful supply of good water is obtained from wells which vary from 100 to 150 feet in depth. Land values vary from $8 to $15 an acre.

Amarillo loam, shallow phase, is not very extensive, though some fair-sized bodies occur in Midland, Martin, and Ector Counties.

AMARILO CLAY LOAM

The topsoil of Amarillo clay loam is reddish-brown or chocolate-brown clay loam, about 8 inches deep. The subsoil to a depth of about 20 inches consists of clay, the color of which grades with depth from chocolate brown to salmon or pink. At this depth it contains chalky particles and merges into soft white caliche at depths varying from 24 to 40 inches. This subdivision into three definite layers is characteristic, but there may be minor variations in the thickness and color of these layers. In a few places, as on slopes, a fourth layer, caliche, may occur.

The topsoil and upper portion of the subsoil are usually noncalcareous, but the lower porition of the subsoil is generally strongly calcareous. In very dry periods the topsoil and subsoil of virgin areas bake into a hard mass. The surface soil forms a mass of small clods which are held together rather lightly and break apart easily. The subsoil is bound more firmly and the clods which break from the mass are larger than the clods in the topsoil. In cultivated fields the surface soil is easily kept mellow with ordinary tillage, although the subsurface layer becomes hard. Both topsoil and subsoil are easily penetrable by plant roots and water.

Amarillo clay loam does not occur extensively here when compared with its extent on the high plains north of the area. However, several bodies aggregating several hundred square miles are in Howard, Martin, Borden, and Dawson Counties at the eastern extension of the high plains. Unimportant areas of Amarillo fine sandy loam, Amarillo loam, Amarillo silty clay loam, and Randall clay are included in mapped areas of this type of soil.

The surface features are those of a rather undulating plain, sufficiently sloping to afford good surface drainage, except in occasional depressions. Subsurface drainage is good, the caliche substratum being easily permeated by water.

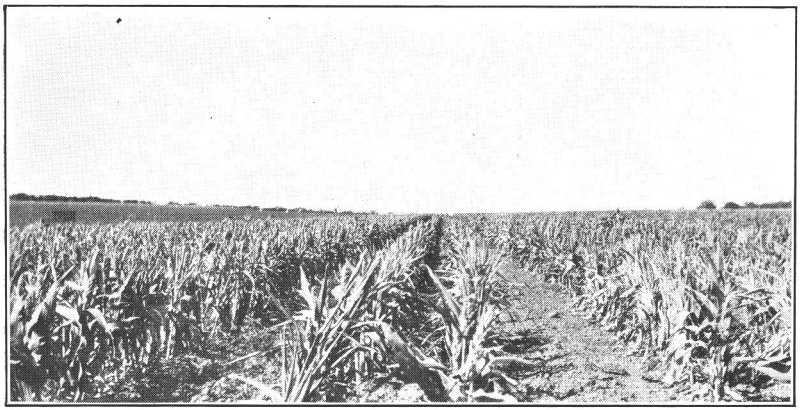

FIG. 1.—SKIP-ROW METHOD OF GROWING GRAIN SORGHUM 2 MILES EAST OF ROTAN

This method is said to produce better yields in dry seasons

FIG. 2.—SUDAN GRASS ON AMARILLO FINE SANDY LOAM, NEAR MIDLAND

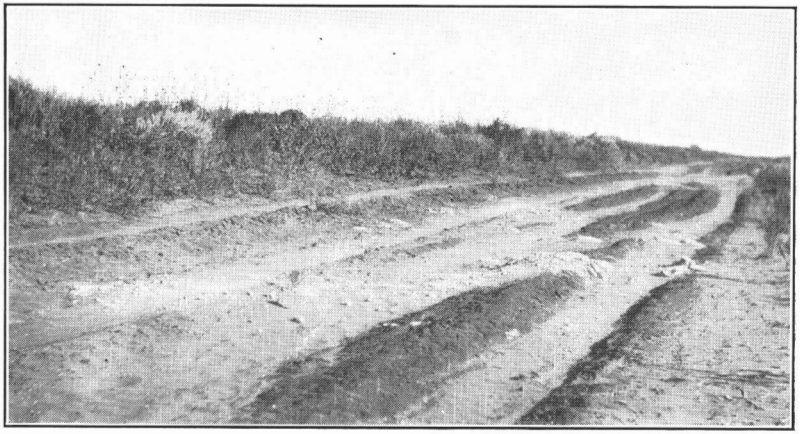

FIG. 1.—CALICHE NEAR THE SURFACE IN AN AREA OF AMARILLO FINE SANDY LOAM, GAINES COUNTY

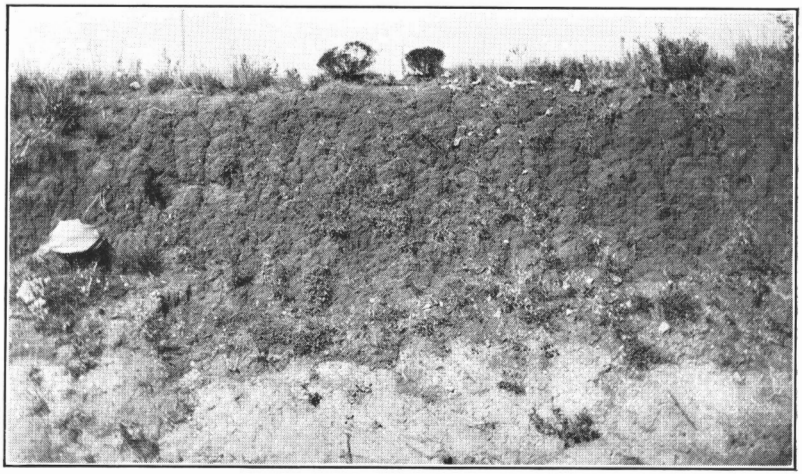

FIG. 2.—A CROSS SECTION SHOWING MILES FINE SANDY LOAM TO A DEPTH OF 6 FEET, IN THE SOUTHEASTERN PART OF SCURRY COUNTY

Amarillo clay loam supports a heavy growth of short grasses consisting largely of buffalo grass, with some grama, curly mesquite, and needle grass. Coarse mesquite grass, or tobosa grass, also grows abundantly in places. Very few mesquite trees and only occasional chaparral growths are seen. Turpentine weeds (Gutierrzia sp.) are abundant and growths of blueweed (*Helianthus ciliaris*), a pest in cultivated fields, are heavy on low places and near areas of Randall clay.

Amarillo clay loam is valued for its natural fertility and ease of cultivation, and it is utilized for a number of crops. Locally it is termed "tight land" in contradistinction to the sandy or lighter and looser soils. Probably not more than 10 per cent is under cultivation, as much of it occurs in areas distant from railroads; but in northern Borden and Dawson Counties, within a few miles of railroads, a somewhat higher percentage is utilized for farming.

The crops grown are cotton, grain sorghum, sorgo, and, to a small extent, corn. These crops do well in seasons of sufficient rainfall, and even in dry seasons with proper cultivation and a good supply of water stored in the topsoil and subsoil.

Cotton yields range from one-third to one-half bale an acre; sorghum, from 20 to 40 bushels; wheat, from 12 to 20 bushels; and oats, from 20 to 60 bushels. Yields of corn are not good except in seasons of plentiful rainfall. All crop yields vary with seasonal conditions, and insufficient rainfall in fall and winter may prohibit a crop of wheat or oats.

Uncultivated areas of this land on ranches are used for pasturing cattle. The grasses are extremely nutritious and cure on the ground, affording excellent winter pasturage. Grass is abundant in most years, and one section of land will ordinarily carry from 30 to 50 head of cattle, and in especially favorable seasons more than 50 head throughout the year.

Amarillo clay loam land is valued at $15 to $35 an acre. Improved farms near towns are held at higher prices.

RICHFIELD LOAMY FINE SAND

Richfield loamy fine sand, typically developed on long, smooth, gentle slopes about Cedar Lake in Gaines County, is brownish-gray, friable loamy fine sand about 1 or 2 inches deep, underlain by brown loamy fine sand or light fine sandy loam, a little hard and somewhat cloddy. At a depth of about 10 inches the material is friable yellowish-gray fine sand. This material becomes lighter colored with depth and very sandy, and soft whitish caliche occurs at depths ranging from 36 to 40 inches. The dry surface soil is very light colored, resembling that of Reeves soils. The material to a depth of about 20 inches does not effervesce with acid.

Near the edge of Cedar Lake is an area of shallow Richfield loamy sand, which consists of light-brown loamy fine sand with some whitish caliche at a depth of 6 to 8 inches. This material becomes somewhat lighter colored with increasing depth, and at depths varying from 15 to 18 inches grades into soft white caliche which contains some fine sand in the upper part. In this location the material is calcareous

from the surface down. The surface dries to a gray color, but the light brown shows at depths of an inch or less. This variation closely resembles Reeves soils. The dry soil to a depth of 6 or 8 inches is a mass of fragile fine clods and a spade may easily be pushed down to its full depth.

Another variation occurs about 6 miles west of Cedar Lake. The surface soil consists of light-brown loamy fine sand 2 or 3 inches deep, underlain by brown loamy fine sand the color of which, at a depth of about 12 inches, is light brown. At a depth of about 15 inches the material is brownish-yellow fine sand of rather loose structure, with some soft white caliche at depths ranging from 18 to 20 inches. White chalky caliche containing some fine sand in its upper part appears at depths ranging from 24 to 30 inches. The structure of the soil is loose for 2 or 3 inches, moderately hard below this, and somewhat cloddy down to the lighter-colored material which is only slightly hard and not noticeably cloddy, and breaks down to a granular mass when disturbed. No effervescence with acid was noted within 15 inches of the surface, but the material is highly calcareous below this depth.

Included in areas of this soil as mapped are patches of light-colored Richfield fine sandy loam, on some eroded slopes patches of whitish Brackett soils, and some small bodies of Randall clay.

Richfield loamy fine sand occurs on comparatively small isolated areas chiefly in Gaines, Ector, Andrews, and Midland Counties, the principal ones lying near Cedar Lake, Shafter Lake, and Seminole Draw. It occurs generally on gentle slopes about depressions and along draws, and on nearly level tracts on the floors of such depressions. In places, as around Cedar Lake, prairie dogs have made little mounds which give a slightly hummocky appearance to the surface.

Scattered mesquite, needle grass, some buffalo grass, turpentine weed, and other weeds constitute the scant vegetation.

By far the greater part of this land is used for grazing. There are a few farms planted to cotton and sorghum near Seagraves and Seminole. When the moisture supply is sufficient, these crops give good results.

RICHFIELD SILTY CLAY LOAM

When dry, the surface soil on virgin areas of Richfield silty clay loam consists of grayish silty clay loam, underlain at a depth of about 2 inches by brown silty clay loam which contains some fine sand. The color gradually grows lighter with depth, so that at about 15 or 18 inches below the surface it varies from pale yellowish-brown to yellowish-gray. At a depth of about 30 inches the material contains some whitish chalky caliche, and about 10 inches below pure white soft caliche occurs. The caliche may appear nearer the surface, especially on the steeper slopes and ridge crests. The material is generally calcareous from the surface down.

The principal body of this soil type has an area of about 10 square miles and is about 10 miles west of Big Spring. Its surface varies from flat to undulating.

The principal vegetation is coarse mesquite (tobosa), needle, and buffalo grasses, with some wire grass, small mesquite trees, and weeds.

This soil is used as pasture land for cattle, although the depressed areas probably could be used successfully for the production of sorghum and cotton.

ECTOR GRAVELLY LOAM

Ector gravelly loam is brown heavy loam from 3 to 15 inches deep, which contains an abundance of gravel consisting of angular fragments of hard and moderately hard white caliche. This gravel is disseminated through the soil, increasing in quantity as the underlying hard white caliche is approached. The surface soil dries out to a brownish-gray color.

The texture in many places is silty clay loam; in others the road beds suggest a whitish soil. Reddish-brown patches in mapped areas of this soil consist of Amarillo gravelly loam. These have not been mapped separately, nor have the few small areas of Brackett soils which occur on steeper slopes where erosion has removed the brown surface layer.

Ector gravelly loam occurs in Ector County as a large body extending westward from Odessa into northeastern Winkler County to the vicinity of Blue Mountain, northward into southern Andrews County, and southward into Crane and Upton Counties. Other smaller isolated areas occur, chiefly in Andrews and Midland Counties.

The surface of these areas varies from level to moderately sloping. The characteristic vegetation is mesquite, chaparral, turpentine weed, and needle and grama grasses. Some cat's-claw grows in scattered clumps and here and there in the western part of the large area west of Odessa there grows a little black brush (*Flourensia cernua*).

This is pasture land and is used solely for grazing. It is too shallow and gravelly to be plowed, and under prevailing conditions too droughty for successful crop production. In good seasons the land carries from 25 to 35 head of cattle to the section. Good water is obtained from wells about 150 feet deep.

The current value of this land ranges from $8 to $15 an acre.

RANDALL CLAY

Randall clay consists of ash-colored clay containing a little sand in some places and grading down into plastic, lighter-colored clay. Some dry areas consist of dark ash-colored clay underlain by lighter-colored clay which is moderately crumbly at depths varying from 8 to 10 inches, but which is more plastic and sticky in the lower, moister depths. The material is noncalcareous, even where on adjacent slopes occur very limy soils.

This soil occurs in depressions (playas) which are usually circular in shape and which are covered with water most of the year. On Edwards Plateau numerous large fragments of limestone are found. Randall clay occurs also as small isolated areas chiefly on the High Plains, most of which are too small to be shown on the reconnaissance map. Some areas are in the flat region of Edwards Plateau and throughout the low plains of the rolling prairie country,

usually associated with the Abilene soils. Only a few of the larger areas are shown on the map.

Dwarf club-rush is the most common plant on these areas. Fine-textured grass resembling buffalo grass springs up here and there after the water has disappeared, and wire grass also is abundant in places. Some better-drained areas, like that southwest of Garden City, support coarse mesquite (tobosa) grass and curly mesquite grass.

Most of this land is utilized for grazing cattle, as it is usually too wet for cultivation. Fairly good corn is occasionally grown in the shallower depressions. Drainage of the deeper depressions would be difficult unless some method could be devised to use underground drainage outlets, as is sometimes done with the depressions in limestone regions.

ABILENE CLAY LOAM

The topsoil of Abilene clay loam consists of dark chocolate-brown, rather heavy clay loam from 4 to 12 inches deep. The upper portion of the subsoil is heavy dark-brown or dark chocolate-brown clay, which has in many places a slightly reddish tinge, and the lower portion is chalky light-colored clay. At depths varying from 3 to 5 feet on flat areas, but less than 3 feet in many places on slopes the material is caliche. In most places the topsoil and subsoil are calcareous.

When moist the topsoil is friable and the subsoil crumbly. In virgin condition both topsoil and subsoil become very hard when dry, but under cultivation the upper 2 or 3 inch layer remains very loose and friable. The hard sun-dried surface soil breaks easily into small fine clods, the upper portion of the subsoil breaks with more difficulty into large and medium clods, and the lower portion of the subsoil breaks into small clods and is somewhat lighter in texture.

A light phase of this soil occurring in northwest Tom Green and in Sterling Counties is included with Abilene clay loam as mapped. This soil is light brown or grayish brown when wet and gray when dry. The underlying caliche is from 18 to 24 inches below the surface, and the light color when dry is probably due to the fact that the entire soil mass is so strongly calcareous. The soil in the narrow valleys of Edwards Plateau is rather young, is somewhat darker than typical Abilene clay loam, is thoroughly impregnated with small fragments of lime, has a gravel substratum, and contains no true caliche.

Abilene clay loam is widely distributed throughout the eastern part of the area in the Rolling Prairie. It occurs in some rather large bodies in northern Runnels, northwestern Nolan, and southeastern Scurry Counties, and there are smaller areas also in these counties and in Jones, Taylor, Mitchell, Fisher, Tom Green, Irion, Sterling, Howard, and Concho Counties. Small areas of associated soils such as Abilene silty clay loam, Abilene clay loam, shallow phase, Miles clay loam, and Roscoe clay are included in mapped areas of Abilene clay loam.

Abilene clay loam occurs on broad, smooth plains ranging from flat to undulating and in small slightly depressed areas. Narrow belts of this soil bordering creeks and draws constitute the greater

part of many small valleys of Edwards Plateau. Drainage is usually good, although in seasons of heavy rainfall water stands for a long time in many places. From an agricultural viewpoint the less well-drained areas are as a rule the most productive. All Abilene clay loam, except that on a few small narrow steep slopes, is cultivable. Good water is obtained from wells ranging from 50 to 150 feet deep.

Abilene clay loam is grassland soil with a scattered growth of small mesquite trees, some chaparral, and scattered bunches of cat's-claw and prickly pear. Mesquite trees grow very thickly in some narrow valleys and on flat or slightly depressed areas. A luxuriant growth of native prairie grasses, consisting mainly of buffalo grass, some grama grasses, and here and there some finer mesquite grasses, covers the ground in most places. A heavy growth of tobosa occurs on flat or depressed areas, and broomweed grows abundantly in many places.

Abilene clay loam is considered productive soil, easily tilled, and adapted to a number of crops. Where it occurs in large bodies, as in northern Runnels County and near Roscoe and Hermleigh, probably 75 per cent of it is cultivated; in other places, as in Sterling and Mitchell Counties, only a small proportion of this land is utilized for farming. It is valuable grazing soil, and in good seasons will support from 40 to 60 or more head of cattle to the section.

The land, where farmed, produces the ordinary crops of the region, such as cotton, sorghum, sorgo, corn, wheat, and oats. All these crops yield well in seasons of adequate rainfall; and even in very dry seasons yields are good on flat areas where a supply of moisture has been stored in the soil. Cotton yields range from one-half to three-fourths bale an acre in favorable seasons and higher where the best cultural methods are employed; and yields of grain sorghums range from 30 to 60 bushels an acre. Sorgo yields large quantities of forage. Wheat and oats are grown in sections where moisture conditions are favorable, and yields of wheat ranging from 15 to 25 bushels and of oats from 30 to 75 bushels are obtained on the better-tilled farms. Sudan grass and various other crops yield well in good seasons. Fruits and vegetables are grown successfully in small home gardens.

Although this soil is very productive it requires some attention to maintain and increase its natural fertility. The deep, flat breaking of the soil at proper times, together with frequent shallow cultivation, will tend to conserve the soil moisture. The plowing under of vegetation will increase the productiveness and water-holding power. The soil mass is readily permeable to water and to roots of growing plants.

Current values for farms on this soil range from $35 to $75 an acre. In ranching sections where much land is still uncultivated, the selling price in large tracts is considerably less. The buildings are good as a rule, and the farmsteads have a general appearance of prosperity.

Abilene clay loam, shallow phase.—The topsoil of Abilene clay loam, shallow phase, is very dark brown clay loam. The subsoil is clay that varies in color from chocolate brown to yellowish brown. Caliche in the form of hard and apparently almost pure limestone underlies this soil at depths ranging from 2 to 24 inches. In some places the brown topsoil rests immediately on caliche, whereas in other places the subsoil intervenes as a layer of rather irregular thickness. Where caliche outcrops on slopes of ridges, small areas of light-colored gravelly loam have developed. Shallow Abilene clay

loam is rather irregular in depth and texture and has been formed by the washing of areas of Abilene soils.

In some areas, such as on margins of the eroded Edwards Plateau or on plateau remnants, caliche is only a few inches thick and rests on hard limestone. In such places it is rather difficult to differentiate between soil of this phase and that mapped as Valera clay. Abilene clay loam, shallow phase, occurs as widely separated bodies in the eastern counties. A large body is in eastern and central Glasscock County extending north into southern Howard County, and small areas in Nolan, Mitchell, Runnels, Concho, Taylor, and Sterling Counties.

This land varies from gently undulating to rolling, with long and gentle slopes. The soil is deepest on small, flat and depressed areas, and shallowest on slopes and ridges. Drainage may be good or excessive.

The native vegetation consists of thinly scattered mesquite trees, chaparral, and a few shrubs, principally cat's-claw and algerita. This is distinctly a plains soil and is covered with a heavy growth of native grasses, mainly buffalo grass and some species of grama and needle grasses.

This soil affords good grazing, and it is estimated that in good seasons it will support from 30 to 40 head of cattle to the section. Probably not more than 1 per cent of this soil is cultivated, most of it being used for pasture land. The soil is so shallow that it is not highly productive, and as it dries out quickly, crops produce only small yields except under the most favorable moisture conditions. Cotton, grain sorghum, and sorgo are the principal crops. Sweet clover could probably be grown for pasturage in many places.

The current value of large areas of this land ranges from $10 to $20 an acre.

ABILENE SILTY CLAY LOAM

The topsoil of Abilene silty clay loam consists of dark chocolate-brown, friable silty loam to depths varying from 12 to 15 inches. In virgin condition, the upper few inches of soil in some places is very dark brown or nearly black because of organic matter. The subsoil consists of brown or chocolate-brown, fairly heavy clay, which may be continuous to a depth of 3 feet, or may be underlain at depths ranging from 18 to 30 inches by yellowish-brown clay. A caliche layer commonly occurs at depths ranging from 28 inches to 3 feet in the older soils of the area. Where erosion has been active, the caliche layer may be exposed or may be present at any depth; but areas of this soil in which the caliche layer is less than 18 inches from the surface have not been mapped as Abilene silty clay loam. When dry, the soil assumes a fine cloddy, friable structure, and becomes grayish in the surface few inches.

In the eastern part of the area, particularly in Runnels County, both topsoil and subsoil show a chocolate or slightly reddish cast, because of the red beds material which forms a part of the sediments constituting these soils. Near areas of Valera soils, this soil sometimes contains fragments of limestone which have been washed from these higher soils.

As mapped in this survey, Abilene silty clay loam includes areas of Abilene clay loam and its shallow phase, Roscoe clay, and Randall clay. These soils are closely associated with Abilene silty clay loam and occur in small adjacent areas, rendering impracticable their separation on the map. In narrow stream valleys where both Abilene silty clay loam and Frio silty clay loam occur as narrow strips, the latter is generally mapped with the Abilene soil.

In virgin areas the surface soil is usually high in organic matter, and both topsoil and subsoil are usually calcareous, although in places the topsoil shows no reaction to hydrochloric acid. This supply of lime causes both topsoil and subsoil to break down into fine clods when dry. If plowed when wet, the soil forms hard clods, which soon crumble upon exposure to the weather. It is fairly retentive of moisture when properly cultivated.

Abilene silty clay loam is a plains soil and occurs on the outwash plains and filled-in valleys of the west-central Texas area. It comprises approximately 25 per cent of the land area of Concho County, 32 per cent of Runnels County, and 45 per cent of Tom Green County. Smaller areas occur in Jones, Irion, Sterling, and Taylor Counties. It occurs on some large continuous tracts, chief of which is Lipan Flat, in the eastern part of Tom Green County and western part of Concho County, covering about 800 square miles. Another large tract extends from San Angelo northeastward to Ballinger, and small areas are north of Ballinger.

Weathering has given to the higher areas characteristics of the upland soils, an undulating or gently rolling surface; whereas the lower and younger terraces, which have been exposed to less erosion, vary from nearly level to gently undulating. Those terraces lying adjacent to the larger streams are nearly level, with only a slight slope toward the main drainage way. Drainage is good in most places, but excessive on some of the higher areas. Good water is obtained from wells from 50 to 150 feet deep.

Scattered mesquite is the chief tree growth, and some live oak is present in places. The scant shrub growth consists principally of algerita, cat's-claw, and chaparral. Prickly pear and yucca are less common. Buffalo and grama grasses form a thick growth over most of this soil, and tobosa is plentiful in places, especially on the more recent flatter terraces and depressions of the prairie. Tall needle grass grows where the soil adjoins areas of shallower or lighter-textured soils. The grass growth is best where the growth of mesquite trees is sparse. *Triodia pilosa* is the earliest grass, having a high value for early spring pasturage, as it comes up thickly after good winter rains.

Abilene silty clay loam is the soil of highest agricultural value in the vicinity of San Angelo. According to analyses made at the Texas Agricultural Experiment Station, it is well supplied with plant food (*3*). A large percentage of this soil in Runnels, Jones, Concho, Coke, and Taylor Counties is under cultivation. It is adapted to and used for all the crops grown in this general region, including wheat, oats, milo, kafir, feterita, corn, cotton, sorgo, Sudan grass, alfalfa, and Johnson grass. In seasons of favorable moisture conditions good yields of these crops are obtained.

Yields of wheat range from 12 to 25 bushels an acre; oats from 30 to 60 bushels; grain sorghums from 30 to 50 bushels; cotton from one-third to 1 bale; and corn from 20 to 30 bushels. In good years two cuttings of sorgo are generally obtained, the yield for each cutting varying from 1 to 1½ tons an acre, and the yield of Sudan grass is about the same. Sudan grass, though not extensively grown as yet, is increasing in importance in the eastern part of the area. Johnson grass is a pest in cultivated fields but has been allowed to grow over large areas for use as hay, yields averaging from 1 to 1½ tons an acre at each cutting, and in years of favorable moisture conditions two cuttings are obtained.

Low terraces along the streams in the Concho basin are irrigated with considerable success. This soil when irrigated is particularly well adapted to cotton, corn, sorghum, alfalfa, Sudan grass, and Johnson grass. However, under irrigation without rotation, alfalfa is subject to root rot and cotton to wilt. With an assured moisture supply and a good system of crop rotation, Abilene silty clay loam would constitute an almost ideal soil for the general farm crops of this region.

This land ranges in value from $25 to $100 an acre, depending on location, improvements, and other local conditions.

MILES FINE SAND

The surface soil of Miles fine sand consists of light-brown, grayish-brown, or pale reddish-brown loose fine sand, underlain at depths varying from 8 to 12 inches by reddish-brown or pale yellowish-red fine sand to a depth of 3 or more feet. When thoroughly dry the surface soil has a grayish cast. Both topsoil and subsoil are loose and give no effervescence with hydrochloric acid. Underlying the soil is chocolate-red rather heavy sandy clay which is nearly everywhere noncalcareous. Several feet below the surface some lime accumulation or caliche probably occurs in most areas of this soil.

Very small areas of Miles fine sandy loam, Miles fine sandy loam, deep phase, and Miles fine sand, shallow phase, were included in mapped areas of this type of soil.

Miles fine sand is not extensively distributed. It occurs on several comparatively small areas on the uplands near Colorado River in southern Scurry and central Mitchell Counties. The land is undulating or gently rolling and in some places is wind-blown or hummocky. Surface drainage is good and subsurface drainage rather excessive.

Although this is treeless soil, in many places a rather thick growth of very low shin oaks occurs. Where the land is locally known as "shinnery land," the principal grasses are broom sedge and needle grasses. Yucca, or bear grass, is abundant in places, and some sagebrush and an occasional small mesquite tree are found.

Less than 5 per cent of this soil is cultivated, most of it being utilized for pasturing ranch cattle or farm stock. Where the land is cultivated the principal crops are cotton, sorghum, and sorgo. The soil is not productive and yields are usually low. In good seasons cotton yields about one-fourth bale an acre, and sorghum from 10 to 20 bushels. The land is suited to the production of fruits, berries, and vegetables, which are raised to some extent with fair success.

Watermelons, sweet potatoes, cantaloupes, and peanuts yield moderately well. Unprotected cultivated fields suffer from the winds which cause sand drifts to cover and kill young plants. This trouble is somewhat overcome by ridging the land and planting crops in the water furrow. Native vegetation furnishes only fair pasturage but will probably carry from 20 to 25 head of cattle to the section in most years.

The current value of this land in the virgin state ranges from $3 to $12 an acre.

Miles fine sand, shallow phase.—Miles fine sand, shallow phase, resembles typical Miles fine sand except in the depth of the surface layer. Light chocolate-red fine sandy clay, which is extremely hard and intractable when dry, usually occurs within 3 feet of the surface. The surface soil is light colored, but the reddish color appears at depths varying from 10 to 15 inches and increases with depth. In places the clay substratum shows some yellowish or yellowish-red mottlings.

Some of the shallower parts of the area south of Anson consist of light grayish-brown fine sand 6 or 8 inches deep, underlain by light reddish-brown or buff-colored loamy fine sand, to a depth of about 12 inches where the material is light chocolate-red fine, but very hard sandy clay. In depressions, the depth to clay ranges from a few inches to about 10 inches, and in some places the sand may have been completely blown off, exposing the clay. White caliche lies within 2 feet of the surface in some of the shallow areas, but ordinarily there is no caliche within the 3-foot depth. Undoubtedly the whole area is underlain by caliche, at depths probably ranging from 4 to 10 feet, according to the topography and the depth of accumulated sand. No effervescence whatever was obtained with hydrochloric acid either in the fine sand section or in the sandy clay. The exposed caliche, of course, is highly calcareous. The soil is low in organic matter.

Only two areas of this phase are mapped. The larger one is between Hawley and Anson in Jones County, and the other is in the west-central part of Jones County and extends into Fisher County. It is associated usually with Miles fine sandy loam.

The surface is gently undulating or slightly rolling. The higher portions have a dunelike configuration and some depressions appear to have been caused by the wind. Under cultivation, the surface soil drifts considerably and collects in small dunes. Drainage is thorough, but fair supplies of moisture are retained in the cultivated soil, often more than in the associated heavier soils.

This is locally called "shinnery" or "shin oak land," as the principal vegetation is shin oak. In addition there is a good growth of scrub hackberry and scrub prickly ash; some few scattered mesquite, small post oak, and blackjack oak; an abundance of sand bur and small leafed, gray mint weed; and a number of coarse grasses mainly broom sedge (Andropogon sp.), needle grass, and bear grass (yucca).

It is estimated that from 10 to 15 per cent of this soil is cultivated, the remainder being used as pasture land. Cotton is the chief crop, and yields range from one-sixth to one-fourth bale an acre, according to the season. Grain sorghums are grown with a fair degree of success, yielding from 5 to 20 bushels. There are several small peach, apple, and pear orchards, and the soil is well suited to plums, which

are grown on small home orchards. Watermelons, cantaloupes, and all kinds of vegetables thrive on this soil. Young crops are sometimes damaged or even destroyed by the sand blown by strong spring winds. Crops are more apt to suffer in seasons of excessive rainfall than in years of moderate precipitation, as the soil retains moisture surprisingly well.

MILES VERY FINE SANDY LOAM

The surface soil of Miles very fine sandy loam, when dry, is chocolate-brown very fine sandy loam from 8 to 10 inches deep. In virgin areas it may be moderately hard to a depth varying from 2 to 5 inches, and below this it is harder and breaks into large clods. This is underlain by darker chocolate-brown heavy very fine sandy loam or light loam, which breaks into clods of varying size. At depths ranging from 20 to 24 inches the material grades into slightly reddish-brown fine sandy clay loam. Soft white caliche is reached at depths varying from 4 to 6 feet. This soil is usually noncalcareous to a depth of 30 inches and is seldom calcareous within a depth of 3 feet.

Some shallow areas are calcareous at the surface, as, for example, the one about 4 miles southwest of Roby, where pure white caliche is reached at a depth of 36 inches. This soil is more easily penetrable than the typical soil when dry, as it has a crumbly or fine cloddy structure in the surface and subsurface layers and a more friable lighter-colored subsoil, especially where there are many caliche particles. In other areas the surface layer of light chocolate-red very fine sandy loam may be only 2 inches thick and underlain by very hard clay, and traces of caliche are then found within a depth of 20 inches. These shallow areas are locally styled "dry spots," and the cotton grown on them is very small in dry seasons.

Miles very fine sandy loam is of small extent in the area, occurring only on a few small bodies in the southwestern and north-central parts of Fisher County in the vicinity of Rotan, Roby, and Claytonville.

The surface is prevailingly flat or gently sloping and gently undulating. It is topographically well suited to cultivation and the drainage is good.

The dominant growth on virgin areas is essentially the same as that on Miles fine sandy loam, rolling phase; that is, a heavy growth of needle grass, some grama and buffalo grass, a little tallow weed, and scattered mesquite trees, cat's-claw, and yucca.

About 60 or 70 per cent of this soil is utilized for the production of cotton, grain sorghums, and corn. These crops do well, although corn suffers severely in dry seasons. This soil has about the same agricultural value and adaptation as Miles fine sandy loam.

MILES FINE SANDY LOAM

Miles fine sandy loam consists of brownish-red fine sandy loam, from 6 to 10 inches deep, underlain by brownish-red sandy clay the color merging gradually to chocolate-red which prevails to depths of 36 inches or more. The lower subsoil is usually light chocolate-red fine sandy loam or sandy clay loam. At depths ranging from 3 to 5 feet, caliche appears. (Pl. LXVII, fig. 2, Pl. LXVIII, fig. 1.)

The surface soil when moist is very friable, but in uncultivated areas the material dries into a rather hard mass. In very dry seasons the subsurface layer of virgin soil below 4 or 5 inches is hard and breaks up with some difficulty into small clods, and the clay subsoil is still harder. Water penetrates the soil easily.

In areas where the soil is on comparatively recent stream terraces no true caliche is present, but there is a zone of lime accumulation represented, in many places, by only small lime or chalky concretions throughout the calcareous clay at depths of more than 2 feet. In many places, the soil is also underlain at depths of several feet by beds of waterworn siliceous gravel, more or less cemented together. In places the hydrochloric acid test reveals no free lime in the 3-foot depth.

This soil is not extensive and comprises a number of small bodies in Jones, Coke, Runnels, and Tom Green Counties. These areas vary from smooth or flat to gently undulating or slightly sloping, and the soil is all cultivable. Drainage is good, and even where the surface is flat, rain water sinks readily into the soil.

The natural vegetation consists of scattered mesquite trees, much cat's-claw, and a heavy growth of grass, principally needle grass and grama grass. Some yucca and a chaparral growth appear in places.

Probably one-half of this soil is cultivated, and the remainder is used for pasture. Farmers are partial to this kind of land, as it is level, easy to cultivate, fairly productive, and suited to a number of crops. Best results have been obtained with cotton and grain sorghum, but the soil is too light for small grains. Yields vary according to the rainfall, but in favorable seasons cotton yields about one-half bale an acre and grain sorghum from 20 to 40 bushels an acre. Small fields of corn produce from 10 to 25 bushels an acre, and in favorable seasons oats afford good winter pasturage, and when allowed to mature yield from 25 to 40 bushels of grain an acre. Sorgo is grown successfully for forage.

The soil is well suited to fruit and vegetable production and these are grown to advantage in small home gardens. Much of this land has been farmed for many years and in places the productivity has been reduced by continuous farming. Being sandy it does not withstand continued cropping throughout long periods of time so well as do some of the heavier soils. A chemical analysis of this soil in Taylor County shows the soil low in nitrogen and in need of legume rotation. (*3*)

The land responds readily to proper treatment such as manuring and supplying organic matter.

The current value of farms on this soil ranges from $25 to $50 an acre.

Miles fine sandy loam, rolling phase.—The topsoil of Miles fine sandy loam, rolling phase, is dark reddish-brown light fine sandy loam, from 8 to 12 inches deep. The upper portion of the subsoil is dark reddish-brown or chocolate-red heavy sandy clay loam material, which at depths ranging from 16 to 24 inches grades into chocolate-red fine sandy clay, and this in places is slightly yellowish red at greater depths. The lower portion of the subsoil may be pinkish, more sandy material containing some lime particles and at

a depth of about 30 inches a considerable quantity of caliche which increases with depth until nearly white or light-pinkish caliche is reached at depths ranging from 32 to 60 inches. The topsoil is noncalcareous except in places where caliche comes near the surface. Ordinarily there is some indication of lime at depths varying from 20 to 30 inches. The topsoil when moist is loose and friable and when dry is very hard and breaks up into small or medium-sized very hard clods. In cultivated soil the immediate surface layer remains friable. The upper and lower portions of the subsoil become very hard when dry, but the soil mass is easily penetrated by rain water.

Virgin soil usually contains a fair supply of organic matter which gives the surface soil a somewhat darker color than that in cultivated fields. Under present methods of cultivation the organic matter is materially reduced, this loss being somewhat greater because the soil is loose and sandy in character and the climate dry and hot. In some places the sand has drifted into low mounds with the result that the entire 3-foot section shows little clay in it, and in other places the topsoil has been blown away, leaving small patches of the clay subsoil exposed. Quartz and ferruginous gravel are found on the surface of some small areas.

Miles fine sandy loam, rolling phase, as mapped in this survey includes small areas of typical Miles fine sandy loam in valleys and on flats; Miles clay loam chiefly along eroded slopes; Abilene clay loam, shallow phase, on narrow ridges and hilltops; Vernon clay loam and Vernon clay on lower eroded slopes; and rough broken land and rough stony land along escarpments where considerable erosion has taken place. Many patches of exposed caliche occur in Nolan and Coke Counties.

Miles fine sandy loam, rolling phase, has a very extensive distribution, occurring as large bodies in the rolling prairies of the northeastern part of the survey, as very large bodies in Scurry and Mitchell Counties, and as smaller ones in Scurry, Mitchell, Borden, Howard, Nolan, Fisher, and Coke Counties.

This land is generally rolling, though in places it is only undulating. The slopes of large areas are gentle and may readily be cultivated. In some counties small bodies are hilly and badly cut by erosion. The soil is easily permeated by water and both surface and subsurface drainage are good, sometimes excessive on steep slopes.

Miles fine sandy loam, rolling phase, is distinctly treeless soil, and the land is covered by a heavy growth of native grasses consisting mainly of needle and grama grasses, with here and there some buffalo grass. In many places a scattered growth of chaparral, small mesquite trees, algerita, and cat's-claw shrubs occur and a few small shin oak shrubs on some of the lighter-textured areas.

This soil is utilized for farming to a large extent, especially in Mitchell and Scurry Counties. Probably about 30 per cent of it is cultivated and in some sections about 60 per cent of the land is in farms. The remainder is utilized for grazing. Cotton and grain sorghums are the principal crops. Some sorgo and small quantities of corn also are produced. Though yields are proportional to the rainfall, the crops, with the exception of corn, withstand dry seasons well on this soil. No commercial fertilizer or barnyard manure is used, nor

is any systematic crop rotation followed. Although the land is fairly drought resistant, it has been demonstrated that existing conditions may be improved by plowing under vegetable matter such as cowpeas or peanuts, to increase the supply of humus in the soil. This would also prevent soil drifting and retard evaporation. The land is well suited to the production of peanuts, but none are grown commercially. Methods of cultivation, such as terracing and contour plowing and planting, should be practiced to prevent surface washing.

In favorable seasons, cotton yields one-half bale or more an acre, and sorghum from 20 to 40 bushels. Corn occasionally yields as high as 30 or 35 bushels an acre, but this is unusual. Oats are grown very little, as the surface soil is rather light for small grains. Vegetables, and orchard fruits, melons, and berries, which thrive on this soil are produced on most farms in small home gardens, some of which are irrigated from wells. Peaches and plums are the most successful tree fruits and many farms have small orchards for home use. Owing to the large number of honey plants, such as cat's-claw, bees are kept on many farms. Good water is obtained on most of this soil at depths ranging from 50 to 120 feet. In some of the lower valleys, an abundance of good water is reached at a depth of about 20 feet. Where ranching is carried on, this soil supports from 25 to 45 head of cattle to the section, or from 75 to 150 sheep or goats.

MILES CLAY LOAM

The topsoil of Miles clay loam consists of chocolate-red clay loam varying in depth from 4 to 8 inches. The subsoil of dark brownish-red heavy clay, which is very sticky when wet and very hard when dry, rests upon caliche from 3 to 5 feet below the surface on flat areas, and within a 3-foot depth on many slopes. The topsoil and subsoil are generally noncalcareous, but in many places where the subsoil at depths varying from 20 to 24 inches is light chocolate-red clay containing chalk fragments, the lower portion of the subsoil is distinctly calcareous.

In virgin areas, the surface soil bakes very hard in dry weather, but in cultivated fields the soil within 2 or 3 inches of the surface remains very loose and friable. The lower portion of the surface soil, though very hard when dry, breaks into small clods with little difficulty; the upper portion of the subsoil breaks with some difficulty into rather large clods; and the lower portion of the subsoil, which is less hard, breaks into smaller clods. This soil is locally referred to as "tight red land," or "chocolate land." The virgin soil has apparently a fair supply of organic matter which gives it a somewhat darker color than cultivated land.

In some areas beds of rounded and more or less cemented quartz and sandstone gravel lie several feet below the surface. Other bodies occur on benches or terraces near stream valleys, and here lime accumulation has not proceeded far enough to develop the pure caliche such as exists on the older areas.

Miles clay loam occurs in areas that are nearly level or gently undulating, though there are some rather steep slopes. Surface drainage is sufficient to allow cultivation at any time. The soil mass is permeable and water sinks into the soil readily though not rapidly.

Miles clay loam is rather widely distributed on the Rolling Prairie of the northeastern part of the area. The larger bodies are in Jones and Taylor Counties; and smaller ones occur in Borden, Scurry, Nolan, Fisher, Runnels, and Coke Counties, and in northeastern Tom Green County.

Included with soil of this type as mapped, are small bodies of other Miles soils and some of the heavier Vernon soils.

Water is usually obtained from wells from 40 to 120 feet deep. In many places, however, the water is "gyppy," owing to the penetration of the well into the red beds beneath the valley-filling material on which Miles clay loam rests.

The native vegetation on Miles clay loam consists of chaparral, scattered mesquite trees, cat's-claw, algerita, cacti, and prickly pear. On some flat ares where moisture may accumulate, a rather thick growth of mesquite trees exist. A somewhat heavy growth of grass prevails over most of this soil consisting of buffalo grass, grama grass, needle grass, and coarse mesquite grass or tobosa grass (*Hilaria mutica*) on some flat areas. Some tallow weed (*Amblyolepsis setigera*), and alfilaria, locally known as filleree (*Erodium texanum*), also grow on this soil.

Owing to the favorable topography and the productiveness of the soil, probably more than 40 per cent of Miles clay loam is cultivated. In Jones County probably 60 to 70 per cent is cultivated, and in other eastern counties from 40 to 50 per cent. Borden County is the exception with less than 5 per cent under cultivation. The main crops are cotton, grain sorghums and sorgo. In good seasons cotton yields range from one-half to three-fourths bale an acre, grain sorghums from 30 to 50 bushels, and yields of sorgo are also large. When rainfall is adequate at seeding time, wheat yields from 15 to 25 bushels, and oats from 35 to 60 bushels.

Many of the farmsteads have small orchards, mainly of peaches, and vegetable gardens irrigated from wells. As this land has been farmed rather exhaustively without fertilizers or manure, the organic matter has been depleted and the soil has become more droughty. Land for crops is usually listed or bedded. Soil fertility could be maintained and built up and drought resistance increased by plowing under organic matter, especially such legumes as cowpeas. Terracing on the sloping areas would prove valuable in preventing surface wash and would allow absorption of a greater quantity of rain water.

In good seasons the range on this soil will carry from 30 to 50 head of cattle to a section.

Improved farms on this soil have a current value ranging from $35 to $50 an acre.

Miles clay loam, rolling phase.—The topsoil of Miles clay loam, rolling phase, is dark reddish-brown clay loam from 4 to 8 inches deep. The subsoil is chocolate-red clay to a depth of 36 inches; but caliche which underlies the soil may come to within a few inches of the surface on slopes. Both topsoil and subsoil are usually noncalcareous. Where uncultivated the topsoil dries into a mass of rather lightly bound small clods which can easily be broken, and the

subsoil into a very hard mass which is broken into large clods only with difficulty. The topsoil is easily kept friable under favorable moisture conditions by cultivation.

Very large bodies of Miles clay loam, rolling phase, occur in Borden, Scurry, and Mitchell Counties, and smaller bodies in adjoining counties. The largest occur around Gail, Snyder, and about 15 miles southwest of Colorado. More than half of Borden County consists of this kind of soil. Many small bodies of typical Miles clay loam, clay, and Miles fine sandy loam, also some other kinds of soil were included with mapped areas of this phase.

This soil occurs on the drainage basins of several of the larger tributaries of upper Colorado River. Erosion has given to the surface a rolling configuration especially near draws and gullies, and smooth or more or less undulating divides lie between these drainage ways. Many small areas are adjacent to stream valleys where the surface is so rough that cultivation is impossible.

The native vegetation is typical plains growth of chaparral, scattered small mesquite trees, cat's-claw, and abundant buffalo, grama, mesquite, and needle grasses. Some of the rougher slopes where caliche lies near the surface, or is exposed, support a growth of little buckthorn (*Microrhamnus ericoides*).

Nearly all this soil is used for cattle grazing, only about 3 per cent on the most favorable and less rolling positions being under cultivation. The cattle pasturage is valuable and rolling areas with deep valleys afford protection to stock during winter. The land will carry from 30 to 50 head of cattle to the section in seasons of sufficient rainfall. The greater portion of this land should remain in ranches. Where the land is farmed, the principal crops are grain sorghums and sorgo for feed for ranch stock, or for sale at local markets. Some cotton is grown with variable success.

The current value of the more rolling land varies in price from $8 to $20 an acre, and some farms in less rolling situations from $15 to $35 an acre.

MILES CLAY

Miles clay consists of dark reddish-brown clay from 8 to 12 inches deep, the color of which gradually becomes chocolate red in the subsoil. Caliche occurs several feet below the surface. Both topsoil and subsoil are calcareous in places, though as a rule the material within the 3-foot depth does not effervesce. Both topsoil and subsoil are very sticky when wet but dry into a very hard mass.

The few small bodies of this soil, with the exception of one in southern Scurry County, are in the eastern part of Borden County.

The surface of Miles clay areas is prevailingly flat, but some dissection by gullies and draws has produced small areas with steep slopes. The surface drainage is fairly good.

The predominant vegetation is coarse mesquite grass, or tobosa (*Hilaria mutica*). Small quantities of wire and needle grasses and a few mesquite trees, also chaparral grow on this soil.

As this is rather heavy droughty soil which would be difficult to cultivate, it is utilized for pasturage in large ranches.

ROSCOE CLAY

The topsoil of Roscoe clay may be black, very dark-gray, or very dark-brown friable clay from 4 to 10 inches deep. The topsoil merges downward into a somewhat finer, denser, and heavier material with scarcely any appreciable change in color. The underlying lime-bearing material is usually caliche at a depth of about 5 feet, but in many places it is only very calcareous clay. In some locations, the subsoil is dark chocolate-brown and certain patches of the lower portion of the subsoil have a reddish color. The topsoil may be calcareous and the subsoil is usually so, but large areas occur where no evidence of lime is apparent in either.

Although in virgin soil there is a thin layer of loose, friable soil on the surface, the topsoil and subsoil bake hard in dry weather and large deep cracks are formed which gradually develop into "hogwallows." Since in cultivated fields good tilth is easily maintained the soil looks like good loam. The subsurface material and the upper portion of the subsoil are very hard and intractable. Clods formed by plowing soon break on exposure to weather, and the lower portion of the subsoil, perhaps because of a slightly larger supply of moisture or lime, or both, breaks apart more easily into fine small clods. There is neither hardpan nor compaction, and water passes readily through the soil. When moist, the topsoil is friable and the subsoil is crumbly; and when wet, the topsoil, though resembling heavy silty clay loam, is somewhat adhesive and the subsoil very sticky.

Roscoe clay is not very extensive. It occurs as a large body in the vicinity of Roscoe in northwestern Nolan County, and extends for short distances into the three adjoining counties. Fairly large areas occur in northern Jones County, and smaller ones in eastern Fisher southern Runnels, and northern Concho Counties. Areas too small to map separately occur within larger areas of Abilene clay loam and Abilene silty clay loam in several counties.

Areas of Roscoe clay are generally flat, though in places very slightly undulating. Many areas occur as slight depressions and others include small lake beds consisting of Randall clay which contain much water in rainy seasons but become dry during spring and summer, and remain so the greater part of the year. Roscoe clay has very poor drainage and in rainy seasons water stands in the depressions, but not long enough to prevent the growing of a crop. In fact, the smooth or slightly depressed surface aids in collecting a large quantity of soil water. Crops grow on the well saturated ground through the succeeding dry season and produce fair yields even if no rain falls after the plants come up. Good water is obtained from wells from 50 to 100 feet deep.

Although many mesquite trees grow on Roscoe clay it is a typical plains soil. A very heavy growth of native grasses consists mainly of buffalo grass, abundant tobosa grass and wire grass in the most poorly drained places, curly mesquite (*Hilaria belangeri*), some of the grama grasses, and a little needle grass. Blueweed (*Helianthus ciliaris*), which grows in spots, sometimes becomes a pest in cultivated fields.

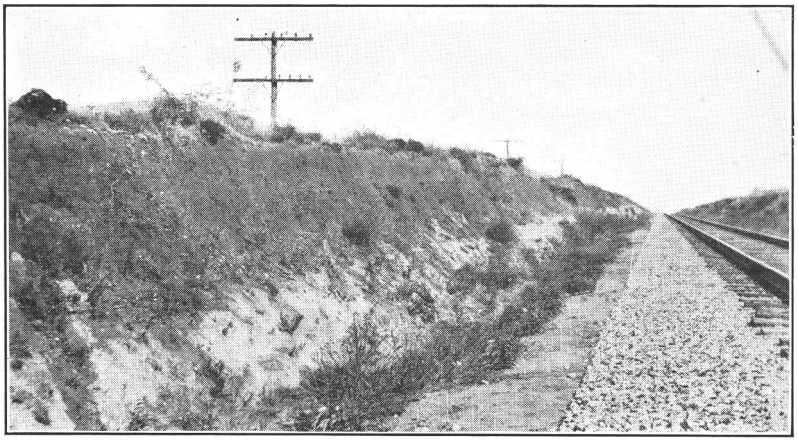

FIG. 1.—CALICHE SHOWN IN A RAILWAY CUT THROUGH MILES FINE SANDY LOAM, 4 MILES SOUTHEAST OF SNYDER, SCURRY COUNTY

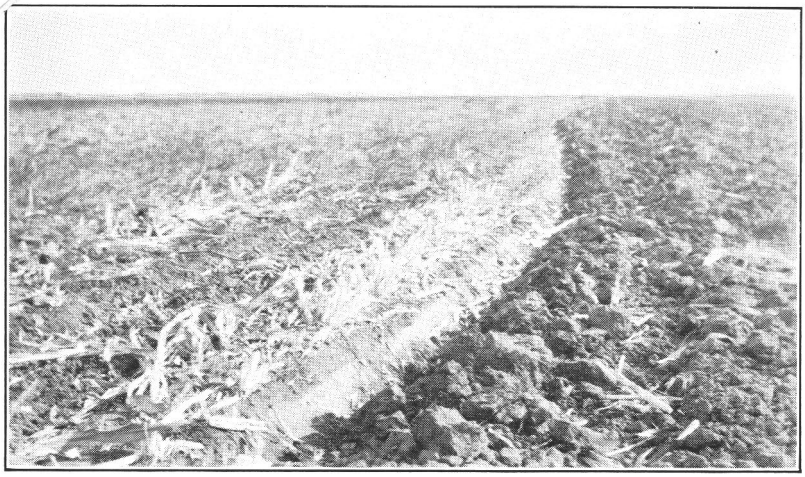

FIG. 2.—ROSCOE CLAY PLOWED ABOUT 7 INCHES DEEP WITH A DISK PLOW

Practice known as "flat breaking." View taken in Nolan County about 4 miles west of Roscoe. Previous crop was milo

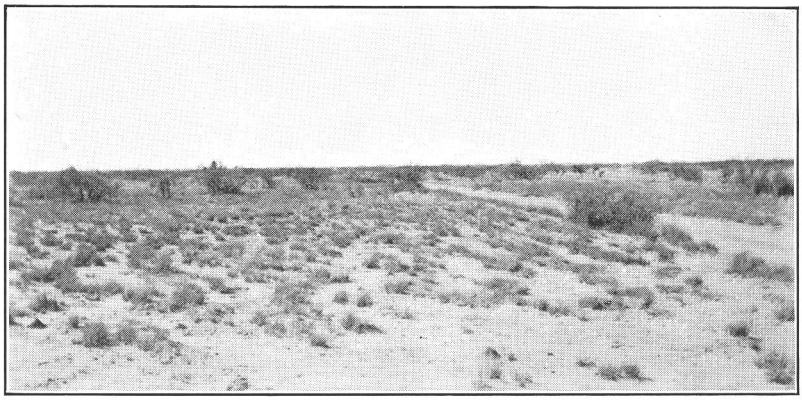

FIG. 1.—VEGETATION ON REAGAN GRAVELLY SILTY CLAY LOAM, ON COWDEN RANCH ROAD, CRANE COUNTY

Vegetation consists of mesquite, purple sage, and some black brush and cat's-claw

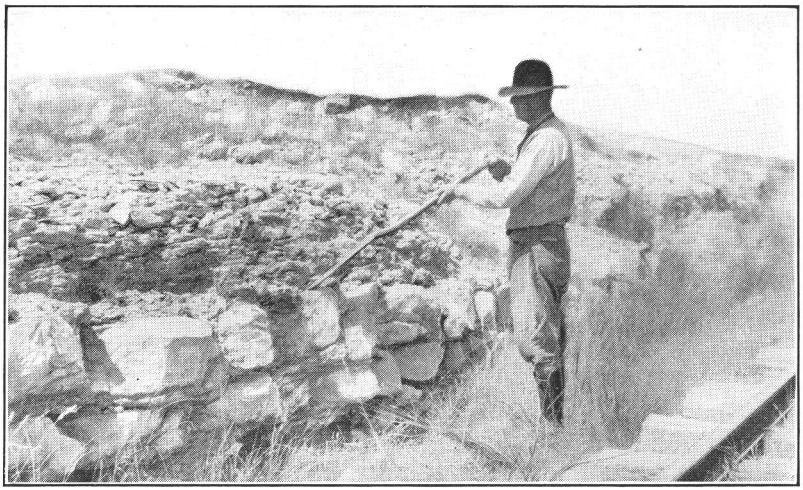

FIG. 2.—CALICHE ON HARD EDWARDS LIMESTONE IN RAILROAD CUT, 8 MILES EAST OF BIG LAKE

Roscoe clay comprises smooth land, and is tilled with comparative ease under suitable moisture conditions. As it will produce crops well even in dry seasons, probably 75 per cent of it is under cultivation. The principal crops are cotton, sorghum, sorgo, wheat, and oats. The soil is well suited to cotton. In good seasons yields reach 1 bale an acre, but ordinarily they range from one-fourth to one-half bale. On a farm about 3 miles west of Roscoe one farmer reports an average yield of one-third bale for the last 12 years. Yields of sorghum range from 20 to 40 bushels an acre. When the rainfall is suitable, corn yields range from 20 to 40 bushels an acre, but little is grown owing to the uncertainty of the rainfall throughout the growing season. Yields of wheat and oats are excellent in good seasons, those of wheat ranging from 15 to 30 bushels and oats from 25 to 70 bushels an acre. Alfalfa would doubtless grow well on this soil in seasons of favorable moisture conditions. Vegetables and fruits are grown in some of the home gardens and small orchards, but the soil is rather too heavy for their successful production.

Plate LXVIII, Figure 2, shows a very good practice of "flat breaking" the land in summer as soon as the sorghum is harvested. This practice adds organic matter to the soil from the crop residue, the soil is rendered loose, and moisture absorption and aeration are increased. Summer tillage is practiced to kill out Johnson grass, which is a great pest when allowed to enter cultivated fields.

The current value of well-improved farms on this soil ranges from $35 to $75 an acre. The general appearance of homes on the farms on Roscoe clay indicate a rather prosperous condition of farmers.

VERNON VERY FINE SANDY LOAM

The topsoil of Vernon very fine sandy loam is dark reddish-brown very fine sandy loam about 10 inches deep. The subsoil consists of lighter-colored, heavy very fine sandy loam material which grades at a depth of 12 or 15 inches into fine sandy clay. This continues to depths varying from 4 to 5 feet, where it is underlain by red beds material, consisting of chocolate-red clay or compact very fine sandy loam containing layers of white, bluish-white, or grayish gypsum and lime carbonate several inches thick and rather hard.

This typical soil profile may be observed on level or nearly level areas, whereas on slopes where erosion has removed some of the true soil, the red beds material comes much nearer the surface. Where the soil material has weathered and accumulated to considerable depth, as on lower gentle slopes and in depressions, the topsoil and subsoil are not calcareous; but where the red beds material occurs near the surface, they are both calcareous. In uncultivated fields both topsoil and subsoil dry into a very hard mass which is broken up with difficulty into large hard clods; but where cultivated, the soil always is loose and friable.

Small areas of loam, clay loam, and fine sandy loam members of the Vernon series, Miles fine sandy loam, and probably Brackett gravelly loam were included with mapped areas of this soil.

Vernon very fine sandy loam occurs almost entirely in northern Nolan and Fisher Counties in a number of rather large bodies, but small areas are in valleys and coves around the base of limestone

ridges and plateaus. These valleys are covered with outwash from higher areas consisting mainly of Abilene and Miles soils. On slopes small exposures of red beds have appeared through erosion, making possible the development of Vernon soils around the base of eroded plateaus and plateau remnants in Nolan, Coke, Taylor, and Runnels Counties, but these patches are too small to show on a reconnaissance map.

Areas of Vernon very fine sandy loam are prevailingly rolling or undulating plains on which cultivation is easy; but some areas adjacent to streams are cut and gullied, and others are so steeply sloping as to be subject to excessive erosion. All the land is more or less subject to erosion and surface drainage allows the rapid run-off of water.

Vernon very fine sandy loam is plains soil, although a scattered growth of good-sized mesquite trees is present, also chaparral, cat's-claw, and yucca. A heavy growth of grasses consists mainly of needle grass (Aristida sp.), grama grasses, buffalo grass, and *Triodia pilosa*. Weeds are abundant, one of the most valuable for grazing cattle being tallow weed (*Amblyolepis setigera*). Of the grama grasses, the most abundant are *Bouteloua hirsuta*, *B. texana*, *B. trifida*, and *B. gracilis*.

Vernon very fine sandy loam is considered good farming soil, well suited to a large variety of farm crops. Probably 50 per cent is under cultivation, and in some localities, as around Roby and Sweetwater, 75 per cent or more is farmed. Where not cultivated, the land is used for grazing. Where farmed, the land is used for the production of cotton, grain sorghums, various forage crops such as sorgo and Sudan grass, and other crops of less importance. Cotton is the most important crop, yields ranging from one-third to 1 bale an acre, depending on the rainfall. Milo is the chief grain sorghum grown, yields range from 25 to 40 bushels an acre, or even more in good seasons. Kafir yields, which are not so certain in dry seasons nor so large as yields of milo, range from 20 to 35 bushels an acre. Sorghum grown for forage produces good yields. Only a small acreage of feterita is grown, but many farmers are beginning to grow an improved variety known as Spur feterita with excellent results. Some wheat and oats have been grown on soil of the heavier phases with fair results; but very little corn is grown, as climatic conditions are unfavorable for maturing a good grain crop. A small acreage of Sudan grass is grown with success by some farmers and is used for pasturage and for hay.

This soil is well suited to vegetables and fruits, and small home gardens and orchards produce fair yields of vegetables, peaches, plums, and pears. The fruit crop, however, is often damaged or destroyed by late freezes.

Vernon very fine sandy loam withstands periods of dry weather very well except where the red beds material comes near the surface. Some farms have been greatly benefited by terracing to prevent erosion and more of the land should be terraced on the steeper slopes. The fertility of the soil could be considerably increased by keeping a good supply of humus in the soil and by growing such legumes as cowpeas.

Some ranching and livestock farming are carried on with success.

Water is obtained from wells from 100 to 150 feet deep, and although most of it contains an appreciable quantity of gypsum it is used freely for drinking purposes. In some sections where wells have been sunk without finding water drinking water is obtained by catching rain water in cisterns, and water for livestock is collected in small reservoirs along draws and watercourses.

Farms on this soil are valued at prices ranging from $35 to $50 an acre and somewhat more in the more favorable locations. The many good farm homes and substantial improvements indicate the agricultural value of this soil.

VERNON FINE SANDY LOAM

The topsoil of Vernon fine sandy loam is dark brownish-red fine sandy loam, which may acquire a distinct grayish cast when dry. The subsoil is dark chocolate-red heavy clay, which is sticky when wet and rather hard and tough when dry. The clay subsoil at depths ranging from 24 to 40 inches rests upon more or less weathered sandstone, the upper portion of which is a hard, compact layer of yellow fine sand, a few inches thick. On some slopes this is present in the 3-foot depth, but on flats it is usually not encountered within 3 feet of the surface. The topsoil is loose and incoherent when moist, but where uncultivated it becomes hard just below the surface in dry weather. The subsoil, too, becomes very hard when dry. The topsoil and subsoil are noncalcareous and there is no indication of lime accumulation or caliche below the 3-foot depth. In places the lower subsoil is mottled red and yellow; in other places, numerous fragments of sandstone are scattered over the surface and throughout the soil mass; and here and there are outcrops of considerable ledges of sandstone beds.

Vernon fine sandy loam is very inextensive. The only body sufficiently large to show on the map was one of a few square miles just east of Blackwell in the southeastern part of Nolan County. Other very small areas in southern Nolan County and adjoining counties were included in mapped areas of Miles fine sandy loam, rolling phase.

The surface of this land is generally undulating or rolling. Some areas are hilly and these are usually very stony. Surface drainage is good, but underdrainage is somewhat slow on level or depressed areas.

Vernon fine sandy loam is a forested soil, having a rather thick growth of post oak and live oak trees and a few mesquite trees. The grass growth is somewhat sparse and comprises species of needle, grama, and other grasses.

The land is used principally for pastures, only about 10 per cent being under cultivation. It is not considered a very desirable soil, but where smoother areas are farmed yields of cotton, grain sorghum, and sorgo are fair. The soil is too light for the production of small grains. Peaches, plums, berries, and vegetables do well in the small home gardens.

This land, in virgin condition, ranges in value from $10 to $20 an acre.

VERNON CLAY LOAM

The topsoil of Vernon clay loam is dark brownish-red clay loam about 10 inches deep, though occasional areas have a thin surface covering of loam 2 or 3 inches deep. The subsoil is chocolate-red clay. In many places the lower portion of the subsoil contains bluish-gray lime concretions. The topsoil is noncalcareous, but the subsoil may show lime. The red beds material, consisting of red clay and shale with some sandstone and white or bluish layers of gypsum, occurs usually below a depth of 3 feet, but on some slopes it is nearer the surface.

Vernon clay loam is not extensively developed in this area. It occurs in several tracts several square miles in extent in northern and southeastern Fisher County, and in smaller areas in Jones, Runnels, Taylor, and Coke Counties. Vernon gravelly clay loam mapped with this soil is indicated on the map by gravel symbols in Taylor, Runnels, and Coke Counties.

The surface is generally slightly rolling with some steep slopes. Even on the more gentle slopes erosion is very active. Surface drainage is good except in a few small flat areas. On account of the uneven surface this soil does not absorb a large amount of rain water.

The open plains on which this soil occurs are characterized by a scattered growth of small mesquite trees and chaparral. Yucca also abounds in thin "gyppy"[9] areas. The grasses are species of buffalo and needle grasses, some *Triodia pilosa* and curly mesquite, and a heavy growth of tobosa (coarse mesquite) on level areas.

Probably not more than 20 per cent of this soil is under cultivation, the remainder being utilized for grazing. It is a rather productive soil where good farming methods have been practiced, but it soon becomes depleted on the slopes unless a rather heavy rainfall is favorably distributed throughout the season.

The principal crops are sorghum and cotton, and some corn also is grown. When moisture conditions are favorable in the fall, considerable wheat and oats are sowed on this land, yielding in a fair season from 15 to 25 bushels of wheat and from 20 to 40 bushels of oats an acre. Sorghum yields from 20 to 35 bushels an acre and cotton one-half bale. Corn yields are usually very low, probably not more than 15 bushels an acre.

The steeper slopes should be left in grass to prevent excessive erosion, and gentler slopes should be terraced. The productiveness of this soil would be increased by the addition of organic matter.

Land values range from $20 to $50 an acre. A higher price might be obtained for better improved farms in the most favorable locations.

VERNON CLAY

The topsoil of Vernon clay is dark chocolate-red very stiff dense clay, which is very hard when dry and sticky when wet. In uneroded areas it is from 6 to 8 inches deep and contains a moderate quantity of organic matter. The subsoil to a depth of 18 inches or

[9] Areas where gypsum occurs in red beds outcrops.

more is chocolate-red clay, also very sticky when wet and very hard when dry. This is underlain by deep chocolate-red or wine-colored clay that may contain much gypsum and partly weathered shale fragments of red beds material, which usually become more abundant with increase in depth until the unaltered red beds strata are reached at depths ranging from 2 to 5 feet. The red beds strata consist of a succession of layers of chocolate-red and yellowish-green clay sandstone, shale, and sandy shale. Vernon clay has a purplish cast in exposed sections which distinguishes it from Miles clay. This soil is usually calcareous, showing slight effervescence with hydrochloric acid at the surface, but more at greater depths. In some places the topsoil has no free lime and the subsoil is but slightly calcareous. The parent material or red beds is always calcareous.

Although Vernon clay bakes very hard in dry weather and wide cracks are formed in cultivated fields, under ordinary conditions the surface layer crumbles or breaks up into fine clods. The plow breaks the hardened subsurface layer into large intractable clods. On some slopes, especially on those along eroded stream valleys where red beds material outcrops in many places, there is not much organic matter in the soil. In northwestern Mitchell County between Cuthbert and Vincent the surface soil is not so heavy as in the vicinity of Iatan and varies from silty clay to heavy clay loam. Rounded cherty fine gravel of igneous rocks occurs on some slopes on higher knolls, along the base of escarpments, and bordering areas of Miles clay loam, but usually the soil is almost free from gravel. Some of this gravel probably has been washed from valley-filling material and some apparently is derived from the conglomerate strata of the red beds.

The main body of Vernon clay occurs along the county line between Howard and Mitchell Counties and extends from Iatan northward to the vicinity of Vincent and Cuthbert. Other small areas are scattered throughout the Rolling Prairie region, many of which are too small to be mapped separately and have been included with Miles clay or Miles clay loam, which are closely associated with Vernon clay. Small areas of Miles clay and Miles clay loam were included with Vernon clay as mapped. Compared with the Miles clay loam and other soils of extensive distribution, Vernon clay is not an important soil.

Areas of Vernon clay may be flat, gently undulating, or sloping, and are steeply sloping along the streams. Here and there the surface configuration has been changed by erosion, which left some small areas along drainage ways badly dissected and others with numerous outcrops of original red beds material and gravelly conglomerates. Drainage is poor on the flat areas, but on sloping and more undulating areas rain water flows away so rapidly that serious erosion takes place. Internal drainage is slow, owing to the compactness of the clay.

Vernon clay supports a growth of chaparral, small mesquite trees, and some allthorn, which are more numerous on the undulating areas but very seldom abundant. The flat and gently undulating areas in seasons of good rainfall support a luxuriant growth of grasses and weeds, the most important being coarse mesquite (tobosa),

Triodia pilosa, needle, buffalo, wire, and grama grasses, and some curly mesquite. In dry seasons the grasses parch quickly. On the more eroded areas all vegetation is scant, the grasses which grow in isolated bunches or spots and the shrubs being dwarfed and scattered.

Very little of this soil is under cultivation, and it is utilized almost entirely as grazing land. It supports from 20 to 30 head of cattle to the section. During wet seasons this number might be nearly doubled, but in droughty years the grass becomes parched and hard, grows slowly, and furnishes scant support to any kind of livestock. Some sheep and goats are pastured, the soil supporting an average of about 90 head to the section. Some of this land is suitable for cultivation, and if handled with care produces fair yields of sorghum, sorgo, and cotton. Small areas are cultivated in Jones and Taylor Counties, where cotton and sorghums are the chief crops. Under favorable moisture and climatic conditions cotton yields about one-half bale an acre, and sorghums from 20 to 30 bushels an acre.

The current value of this land varies with its topography and its location with reference to towns and roads. The best areas are locally valued at the time of the survey (1922) at prices ranging from $8 to $20 an acre, and more eroded or isolated areas may be purchased for $3 an acre.

VALERA SILTY CLAY LOAM

Valera silty clay loam consists of dark-brown or black clay, underlain at depths varying from 12 to 18 inches by indurated caliche. The caliche in turn rests upon limestone usually at depths of less than 3 feet. Generally the color of the soil grows lighter with increase in depth, and in places there is a thin layer of reddish clay over the caliche. The supply of organic matter is fair. In its general features this soil is similar to Abilene silty clay loam, and the boundaries between the two are not sharply defined. Many areas mapped as Valera silty clay loam are in reality areas of Abilene silty clay loam in which the limestone lies beneath the caliche at rather shallow depths.

Valera silty clay loam occurs on flat or nearly flat areas in the Edwards Plateau region. The natural vegetation, crop value, and tillage requirements are very similar to those on Abilene silty clay loam.

VALERA STONY CLAY

The topsoil of Valera stony clay is clay which may vary in color from light brown to very dark brown. It is from 4 to 10 inches deep and contains limestone fragments usually several inches in diameter and fine lime particles, which give to it a gray or nearly white color when dry. The subsoil consists of hard limestone or limestone layers alternating with chalk or marly strata, or there may be an immediate subsoil of semi-indurated limestone or hard chalk resting on hard limestone. On many slopes ledges of massive or laminated limestone outcrop, giving rise to areas of rough stony land that are too small to show separately on the map. Small areas of Brackett

stony clay, Valera clay, shallow phase, and Abilene clay loam in narrow valleys have been included in mapped areas of this soil.

Valera stony clay is very extensive, occurring in the greater portion of the old high limestone region known as Edwards Plateau. There are, also, large areas in Concho, Tom Green, Irion, Sterling, and Coke Counties, and smaller ones in Nolan, Taylor, Mitchell, Reagan, and Glasscock Counties.

Most Valera stony clay land is very rolling, the slopes ranging from gentle to rather steep. Some tracts on ridges or on the edge of divides and table-lands are fairly smooth and nearly level, whereas others have a terracelike configuration. Many small streams dissect the areas, and erosion is so active as to remove the soil material nearly as fast as it is formed from the weathering of the underlying limestone. Springs having a small flow of water occur in the ravines or gullies which extend through the soil, but as a rule the stream beds are dry except just after rains.

Usually a rather thick growth of shrubs is supported by this soil, consisting in places chiefly of small cedar (juniper) trees, and in other places of thick clumps of small shin oak trees only a few feet high. Chaparral and some thorny shrubs, cat's-claw, algerita, yucca, cacti, Shawnee haw, sumac, and other bushes abound. On the steeper eroded slopes very little grass grows, on the more gentle slopes the grass growth is luxuriant, and in the numerous slight depressions, where much soil material has accumulated among the rocks, there are fairly heavy growths. The grasses comprise tall needle grass, buffalo grass, and *Triodia pilosa*. A variety of weeds grow here, some of which, such as alfilaria and tallow weed, are valuable in affording pasturage for sheep and cattle. In southern Tom Green and western Concho Counties is a fairly dense growth of live oak trees. In many places redbud (*Cercis occidentalis*) grows on the rougher areas.

Valera stony clay is utilized entirely for grazing, as it is too stony for cultivation, and it is all included in large ranches. Cattle, principally, are grazed, though in some sections many sheep range on the same land with cattle, or alone. A section of this land carries from 35 to 50 head of cattle or about 300 head of sheep in good seasons. Herds of goats are grazed on this land in the southeastern parts of the area. (Pl. LXIII, fig. 2.)

This land ranges in price from $5 to $20 an acre, and rental from 15 to 20 cents an acre.

VALERA CLAY

Valera clay consists of a layer of brown or dark-brown clay from 10 to 12 inches deep resting on hard caliche underlain by limestone or on limestone itself. Some variations occur in which the surface soil rests on limestone at a depth of 3 or 4 inches, and others where it grades into yellowish-brown or brown clay which rests on limestone or caliche at depths varying from 12 to 18 inches. In many places small fragments of limestone or hard caliche are scattered throughout the topsoil and subsoil. The fine earth material of the soil mass is highly calcareous. Small areas of Valera stony clay and Abilene clay loam, shallow phase, are included in mapped areas of this soil.

Bodies of Valera clay are scattered throughout the southeastern part of the area in the Edwards Plateau, occurring usually on the margins of limestone areas. Large bodies occur in eastern Runnels and eastern Concho Counties, and smaller ones in southwestern Nolan, southern Mitchell, northern Sterling, and southwestern Coke Counties.

The surface of Valera clay land is rolling. Small draws and gullies which cut the rolling areas make drainage exhaustive and cause erosion of the soil material almost as fast as it is formed.

This rolling plains land is covered with a fairly good stand of valuable pasturage grasses, consisting of needle and buffalo grasses, some *Triodia pilosa*, and other grasses. Some of the numerous weeds also afford food for cattle. There are a few mesquite trees, scattered small cedar, cat's-claw, and yucca shrubs, and a growth of live oak in places in the southeastern part of the area.

Valera clay land is utilized almost entirely for pasture land on large cattle ranches. It will support from 30 to 40 head of cattle to the section in good seasons. Cultivation has been attempted on only a few areas indicated on the map by this type of soil, on fields comprising other types of soil. In a season of plentiful rainfall, fair yields of grain sorghums and sorgo could probably be made on the deeper soil. Sweet clover would be a valuable adjunct to the natural pasturage, and in some seasons this could be grown with fair success, especially in small depressions and spots where the topsoil is deepest. This kind of land ranges in value from $8 to $20 an acre.

ABILENE AND VALERA CLAYS, UNDIFFERENTIATED

The soil material in areas of undifferentiated Abilene and Valera clays is brown or dark-brown clay, the color of which, at a depth of about 10 inches, grades to yellowish brown, this color prevailing to a depth of 36 or more inches. This material usually rests on limestone, or hard caliche which resembles limestone, at a depth less than 3 feet, and in some places not more than 15 or 20 inches. Both topsoil and subsoil are highly calcareous. In places the soil material is several feet deep, but on many slopes or ridges it is shallow. A few limestone fragments occur in places on the surface and throughout the topsoil and subsoil.

When wet these soils are very sticky, but when cultivated they have good tilth, and during dry seasons the surface soil is very light fine clod mulch to a depth of 2 or 3 inches. Where uncultivated the topsoil and subsoil become very hard and firm on drying. The topsoil of rather lightly bound small clods can be broken easily, but this is not true of the subsoil mass of large clods. The surface layer of virgin soil is slightly darker than the subsoil and apparently contains considerable humus.

Included with inextensive mapped areas of these soils are small patches of Crawford clay which is very similar to Valera clay except that it is red or reddish brown in color, Valera stony clay, and Randall clay.

The largest areas are in northeastern Sterling County and southern Nolan County and several smaller areas are in western Coke, southwestern Concho, and southern Sterling Counties.

The plateau remnants of sections of Edwards Plateau on which these soils occur are rather flat or undulating, and drainage is good. Ravines and draws work back from the edge of the main areas into the uneroded plateau, gradually removing the soil material and exposing the underlying rocks. Much of the surface drainage goes into the rather numerous small lake beds. As a rule, much of the soil is deep enough to constitute a fairly good reservoir for soil water, and doubtless much moisture comes up from the lower marly layers through the crevices in the hard interbedded layers of limestone. Good water is obtained from wells at depths varying from 50 to 200 feet.

The native vegetation consists of a few small mesquite trees, occasional chaparral, and a heavy carpet of short grasses and weeds which afford very good pasturage. The principal grasses are buffalo grass (*Bulbilis dactyloides*) and curly mesquite (*Hilaria belangeri*), and there are smaller growths of *Triodia pilosa*, needle grass, coarse mesquite grass (*Hilaria mutica*), and wire grass or vine mesquite (*Panicum obtusum*).

Probably 65 per cent of this land is under cultivation and the remainder is used for cattle grazing. The included dark soil, generally referred to as "black land," is fairly productive, especially where it is deep. Areas where the underlying rock lies near the surface are less drought resistant than those where the soil is 3 or more feet deep. The soil, although heavy, withstands dry seasons very well, especially if a good supply of water is stored in the soil and thorough cultivation is given.

The main cash crop is cotton, yields ranging from one-third to one-half bale an acre and sometimes more when moisture conditions are favorable. Plate LXIV, Figure 1, shows cotton on these soils in a very dry season. Sorghum, of which milo is the principal variety, ranks next in importance. Milo yields range from 25 to 35 bushels an acre. Small acreages of sorgo are grown for fodder by most farmers and good yields are obtained. Corn is very uncertain owing to the usually dry weather in early summer, but in fairly good seasons from 20 to 35 bushels to the acre have been produced. Some wheat and oats were formerly grown, but the acreage in these crops is negligible. Some Sudan grass is grown, and as it has proved a successful and valuable crop it deserves a wider use as an adjunct to other forage crops. Areas of deeper soil would probably produce alfalfa, but moisture conditions are not favorable in some years and the crop has been given but few trials. Fruit has not been very successful in the small home orchards owing to late freezes and other unfavorable conditions. Gardens are planted on all farms and vegetables thrive especially where they receive a little irrigation from wells.

These soils seem well suited to the production of small grains and broomcorn, but probably the climatic and economic conditions are not favorable for the production of these crops on a commercial scale. The farms are usually about 160 acres in size and most of them are operated by the owners, who have fairly good homes and substantial farm buildings. Current land values vary from $35 to $50 an acre where improved, in Nolan County, and are considerably less in other parts where not so much land is improved.

REEVES FINE SANDY LOAM

Reeves fine sandy loam consists of light-brown fine sandy loam from 8 to 10 inches deep, underlain by light-buff or yellowish-brown fine sandy clay or fine sandy clay loam material to a depth of 36 inches or more. When dry the topsoil and subsoil become rather compact, and when moist the soil is rather friable and has good tilth. The soil is low in organic matter, and effervesces with hydrochloric acid. White caliche usually occurs at a depth of several feet, but in a few places it is within 15 or 20 inches of the surface. The caliche is soft in most places, but in others it constitutes hardpan which prevents the ready absorption of soil water. Small areas of Reeves chalk and Reeves gravelly loam are included with this soil as mapped.

Areas of Reeves fine sandy loam are rather inextensive, and occur around Barstow and Grandfalls, in the wetsern part, and in various sections of Loving, Ward, Winkler, and Crane Counties in strips from 1 to 5 miles wide.

The surface of Reeves fine sandy loam land is flat, gently sloping, or very slightly undulating. Although the surface soil absorbs water readily, both surface and subsurface drainage are poor because of the hardpan substratum. Unless irrigated land is artificially drained, soluble salts become concentrated at or near the surface. This was the case at Barstow and Grandfalls, where the results obtained by irrigating were good and warranted ditching to drain the land of salts which collected in detrimental quantities. Information obtained at Barstow shows that the drainage system necessary to prevent the excessive accumulation of salts, consisted of ditches about 6 feet deep and about three-fourths of a mile apart.

Reeves fine sandy loam land is somewhat lower than the surrounding soils and it receives some seepage from them. Much of this soil occurs along the Pecos River bottom lands and has somewhat the appearance of an old river terrace. There is no marked terrace line or bank, however, between this and the alluvial soil of the river bottom land.

The native growth consists of mesquite trees, chaparral, bear grass (yucca), Brigham tea (Ephedra sp.), greasewood, and grasses, the principal ones being needle grass, burro grass, salt grass, and grama grass. The grass growth is not abundant, but the weed growth is rather heavy.

About 18,000 or 20,000 acres of this soil is in cultivation and under irrigation near Barstow and Grandfalls. Irrigation water is taken from Pecos River. About 75 per cent of this area is in cotton and the remainder is in alfalfa. Cotton yields vary from one-fourth to more than 1 bale an acre, and alfalfa from 3 to 6 tons an acre from five cuttings each season. The best cotton yields are obtained following alfalfa and yields decrease with each successive planting of cotton on the same land. The principal varieties of cotton are Mebane, Acala, and Lone Star. Peaches, watermelons, cantaloupes, and sweet potatoes yield well, but fruits and vegetables have been grown only on a small scale. Good crops of excellent Tokay and Malaga grapes are produced. With a larger and more uniform supply of irrigation water, various crops could be successfully grown

on this soil. A large proportion of the land is utilized for ranching purposes and supports from 20 to 25 head of cattle to the section the year round when the rainfall is sufficient to produce a good growth of grass.

REEVES GRAVELLY LOAM

The topsoil of Reeves gravelly loam is from 6 to 12 inches deep, and consists of light-brown or grayish-brown loam containing a large quantity of angular fragments of white chalk, the fine earth material being by far the smaller constituent. In many places the topsoil is free from gravel fragments within 1 or 2 inches of the surface.

The subsoil is buff-colored or light-brown loam containing many rather hard chalk fragments underlain by solid beds of hard chalk or caliche which closely resembles limestone. In some places both topsoil and subsoil contain rounded quartz gravel, and in other places the subsoil consists of hard caliche in which there may be small rounded gravel or a cherty layer. Mapped areas of this soil include areas of Reeves gravelly fine sandy loam which would have been mapped separately except that its agricultural value and adaptation are similar to Reeves gravelly loam and the survey is not sufficiently detailed.

Reeves gravelly loam is rather extensive, occurring in large bodies in Loving, Ward, and Winkler Counties, which extend southward beyond the boundaries of the survey into Reeves and Pecos Counties.

Areas of Reeves gravelly loam may be gently rolling or undulating, occurring on broad gently rolling ridges or swells rising from the level plain where other Reeves soils occur. Very few of the slopes are steep, though narrow areas along some of the draws are sufficiently steep for the underlying caliche to be exposed by erosion. In a few places in Ward County the steeper slopes show outcroppings of red sandstone in the Red Beds. This has been quarried for building stone and is used locally in construction.

The soil has excellent surface drainage; in fact, the removal by erosion of the fine surface soil has been an important factor in the formation of this soil. The percolation of soil water is very slow and the impermeability of the hard caliche may render it impossible in many places.

The native vegetation is rather scant, most of it being low shrubs of little grazing value. The grass growth is scant and a number of weeds infest the soil. The vegetation consists of greasewood or creosote bush (*Covillea tridentata*) and scattered small mesquite trees; some cat-claw and yucca; a sparse growth of burro grass (*Scleropogon brevifolius*), needle grass, and salt grass (*Sporobolus airoides*); and an abundance of snakeweed and little buckthorn.

Reeves gravelly loam is utilized only for the scant pasturage it affords. It is not cultivated, as the shallow soil is unsuited to cultivated crops, especially in a region of low rainfall. The native vegetation supports only 15 or 20 head of cattle to the section. Plenty of fairly good water is obtained at depths of about 150 feet, lifted by windmill pumps.

Current values of this land in large tracts varies from $4 to $8 an acre, and leases for pasturage from 10 to 15 cents an acre.

REEVES CHALK

Reeves chalk is white or cream-colored soft chalky material to a depth of more than 3 feet, apparently composed largely of gypsum. Throughout this chalky material are hard layers which represent the "gyppy" caliche that appears under Reeves soils where exposed by wind or water erosion. The surface has a thin semihard crust about one-eighth of an inch thick. In places the lower part of the vertical section is salmon colored and reveals particles of hard material, with here and there some small rounded quartz gravel, and other crystalline rocks.

Comparatively small tracts of this soil occur in the western part of the area, the largest being west and south of Pyote in central Ward County. Other smaller areas are in Ward, Loving, southern Crane, and Winkler Counties.

Reeves chalk occurs on steep slopes and broad, gently sloping ridges or swells in the plain. The large area near Pyote, however, is flat and basinlike and is surrounded by slightly higher areas of other Reeves soils. Drainage is generally good. Good water is plentiful at depths ranging from 100 to 150 feet.

The native vegetation consists of a very sparse growth of greasewood, cat's-claw, yucca, mesquite shrubs, little buckthorn, small weeds, and needle grass.

This land comprises large tracts and is utilized only for the very scant grazing it affords, as it has no value for other agricultural purposes. No separate value is given for land of this type, as it is sold with other land of more importance. It tends to detract from the value of tracts on which it occurs. The rental for the leased grazing land is from 10 to 15 cents an acre.

REAGAN GRAVELLY SILTY CLAY LOAM

Dry Reagan gravelly silty clay loam consists of a surface layer from one-fourth to 1 inch thick, of light-buff, fine, cloddy, silty clay loam, underlain by chocolate-brown or light-brown harder silty clay loam in larger clods. At depths varying from 10 to 12 inches the material is yellowish-brown or brownish-yellow, finely cloddy or crumbly silty clay loam, underlain at depths ranging from 12 to 24 inches by hard white caliche. Fragments of hard or moderately hard white caliche occur on the surface and throughout the topsoil and subsoil, causing the material to be highly calcareous. In places white caliche overlies pale-yellow limestone.

This soil as mapped includes many bodies of shallow Valera gravelly clay, Valera stony clay on slopes, and rough stony land. Limestone and sandstone fragments are scattered over the slopes and many ledges of these rocks outcrop.

Reagan gravelly silty clay loam on long gentle slopes grades to Reagan silty clay loam which occurs as strips along drainage ways. These lower areas support a heavier growth of vegetation than higher and more extensive ones.

This soil occurs in large bodies in southern Upton County, and smaller bodies in southern Midland, southeastern Crane, and southwestern Reagan Counties. The surface is flat or gently undulating,

but becomes more sloping as it approaches included areas of Valera soils. Much of this soil occurs on a broad somewhat flat area which represents a gradational soil zone between south High Plains and Edwards Plateau.

The characteristic growth is chaparral, mesquite trees, little buckthorn, black brush, Brigham tea, yucca, and needle grass. The higher areas support a scantier growth of the same vegetation. Turpentine weed, or tarweed, and croton weed are abundant. Plate LXIX, Figure 1, shows this vegetation.

All this land is used for grazing, but the grass growth is scantier than on Reagan silty clay loam. Some of the lower sloping areas which are partly colluvial could be farmed, but generally the soil is best suited for raising cattle and sheep. Good water is obtained from wells. Current values of this land probably range from $3 to $10 an acre.

REAGAN SILTY CLAY LOAM

When dry the topsoil of Reagan silty clay loam consists of ash-colored, or fawn-colored, fine, cloddy silty clay loam from one-half to 1 inch in thickness, underlain by brown, hard cloddy silty clay loam to a depth of 5 or 6 inches. The subsoil may be crumbly or finely cloddy silty clay loam or silty clay, the color gradually changing with depth from light brown or pale buff to yellowish brown or pale brownish yellow, and the quantity of soft white caliche increasing until soft, white, pure caliche is reached at depths ranging from about 24 to 48 inches. In many places this caliche is mixed with some pale brownish-yellow silty clay loam material. This soil is highly calcareous, effervescing freely with hydrochloric acid. No gypsum, such as is frequently seen in the white layer underlying Reeves silty clay loam, is distinguishable in the topsoil or subsoil at any depth. The caliche has in many places a very faint pinkish cast.

No distinct demarcation exists between this and adjoining Abilene soils. The color of the topsoil grows darker and takes on a chocolate cast near Abilene silty clay loam. A variation of Reagan silty clay loam occurs about 8 miles east of Big Lake, where the topsoil is darker in color and from 12 to 18 inches deep, the appearance of caliche fragments is rather sudden, and at depths varying from 24 to 30 inches the soil material is entirely replaced by accumulations of soft white caliche. In a few places the soft white caliche is definitely capped with a very hard thin stratum of caliche. The caliche is usually harder in shallow areas than in deeper areas. Hard pale-yellow limestone (possibly a member of the Edwards limestone formation) lies beneath the limestone in areas where the soil is shallow. (Pl. LXIX, fig. 2.)

There are many slight depressions where the soil is more brownish, holds moisture better, and supports a heavier growth of vegetation. What is probably a colluvial phase of this soil occurring in depressed flats through which drainage water finds its way was included with this soil in mapping. Most of it, as that occurring as strips northwest of Rankin and in the vicinity of the McElroy ranch headquarters, has a topsoil of brown silty clay loam in small hard clods fairly firmly bound, underlain at a depth of 2 or 3 inches by brown

silty clay loam of larger-sized hard clods. At depths ranging from 8 to 12 inches light-brown silty clay containing some rounded limestone and sandstone gravel appears. The subsoil is moist in many places and fairly friable or crumbly when the topsoil is hard. Grass on these areas remains green when that on adjacent lighter soil becomes parched.

Reagan silty clay loam occurs in a large body extending westward from the western border of Irion County across Reagan and northern Upton Counties, and northward into southern Glasscock and Midland Counties. It lies in a transitional position between High Plains on the north and Edwards Plateau on the south, extending southward as the crests of flat divides of the Edwards Plateau drainage system. The included brown colluvial phase of this soil extends into the eastern part of Crane County.

The surface of this land is level. Here and there are faint gradients toward local depressions, on which Randall clay occurs. The colluvial areas in drainage way depressions are either flat or slope very gently toward the central or lower part of these depressions where there are narrow strips which in a detailed survey would be classed as a phase of Frio silty clay loam. Small hummocks of mixed caliche and soil are common around mesquite and other shrubs. These little mounds are honeycombed with the holes of ground squirrels and rats which have brought the material up from below.

The vegetation on Reagan silty clay loam is characteristically that of the arid or very dry region west of Pecos River. The predominant growth on the western area in Upton County is black brush (*Flourensia cernua*), locally called "broadleaf sage," "sweet-scented greasewood," or "greasewood." It forms a very dense growth, almost to the exclusion of all others in some places, as does tobosa grass where natural surface drainage is poor. It is associated with a few small mesquite trees, chaparral, short needle grass, and some buffalo grass.

In other places mesquite trees, chaparral, and various shrubs, such as Brigham tea (Ephedra sp.) and allthorn, constitute the principal growth, with some associated black brush, croton weed (*Croton texense*), tarweed (Gutierrzia sp.), and little buckthorn (*Microrhamnus ericoides*). The mesquite trees and chaparral are tallest and most abundant on the lower and more brownish areas. Allthorn is most commonly found on the higher situations with shallow soil, as are also little buckthorn, yucca, and Spanish bayonet. The common vegetation of the drainage depressions consists of mesquite trees, chaparral, clematis vines, black brush, yucca, buffalo grass, and curly mesquite grass. The eastern extension, where the soil is darker, as in southern Glasscock and eastern Reagan Counties, has the heaviest growth of grasses and little or no black brush. Toward the west the grass becomes less abundant, the mesquite trees fewer, and black brush much more abundant. A small plant, *Perezia nana*, is rather persistent in places.

Practically all this land is used for grazing, more being used for cattle than for sheep, and unless irrigation can be provided cheaply most of the land should continue to be used for this purpose. It carries from 15 to 30 head of cattle to the section. The soil of included

depressions and the colluvial phase along the drainage ways, however, can be farmed, and probably most of it could be planted to sorghum for use as a supplementary feed for livestock in droughty seasons and cold winters. Some fairly good sorghum was seen on the colluvial soil on McElroy ranch. Cotton also can be grown on the darker-colored areas. With irrigation these strips of lowland could be made to produce abundant crops even in the driest years, and a large part of them could be irrigated from wells. An abundant supply of water is available throughout the area from wells seldom more than 100 feet deep.

Only a few small tracts of Reagan silty clay loam are cultivated, and good yields of sorghum and sorgo are obtained in seasons of sufficient rainfall. With an adequate moisture supply this soil would probably produce good yields of cotton, wheat, and oats.

Land values vary from $5 to $15 an acre. The land is all in large ranches and settlement is very sparse.

Reagan silty clay loam, light-colored phase.—This soil is much like Reeves clay loam, light-brown, light-buff, or brownish-gray silty clay loam, underlain at depths varying from 8 to 12 inches by light-buff or yellowish-buff silty clay loam, which is continuous to depths of more than 36 inches and may contain pink and white gypsum particles. Both topsoil and subsoil are very light colored and crack to a cloddy condition on drying. The topsoil becomes rather hard and compact when undisturbed but is friable when tilled. White caliche or chalk beds consisting largely of gypsum occur in most places at depths ranging from 3 to 5 feet, but in some places they come within 26 or 28 inches of the surface. The soil is low in organic matter. Both topsoil and subsoil are somewhat calcareous.

The one small area mapped is about 3 miles southeast of Pyote in south-central Ward County.

Characteristically the surface is smooth, but has sufficient slope for fairly good drainage.

The soil is covered with typical western arid vegetation consisting of black brush (*Flourensia cernua*) and creosote bush (*Covillea tridentata*), and burro, needle, and buffalo grasses.

None of this type of soil is under cultivation.

MILLER FINE AND VERY FINE SANDY LOAMS, AND MILLER SILT LOAM, UNDIFFERENTIATED

In this area about 15 per cent of the soils of the Miller series occur in patches so small and so intimately associated that they are not differentiated on the map.

Miller fine sandy loam consists of reddish-brown topsoil from 10 to 15 inches deep, and chocolate-red subsoil which may be fine sandy loam or fine sandy clay. Miller very fine sandy loam has chocolate-red very fine sandy loam topsoil about 10 inches deep, underlain by subsoil of nearly the same color and texture. When dry, both topsoil and subsoil become rather hard, but where cultivated the subsurface layer is rather loosely cloddy and the subsoil friable. The topsoil in cultivated fields in very dry seasons is loose to a depth of about 2 inches; below that, it is rather hard but breaks up easily into fine clods.

Miller silt loam is chocolate-brown silt loam, which at a depth of about 12 or 14 inches has a reddish tint which prevails to a depth of 36 inches or more. The percentage of silt increases with depth. In uncultivated fields the topsoil and subsoil become hard and are broken with difficulty, but they are not compact or impermeable to water. In cultivated fields, to depths varying from 2 to 6 inches, the surface soil remains mellow, the subsurface soil becomes rather hard and is broken with some difficulty into small clods, and the subsoil is slightly hard and easily broken into fine clods. Very small areas of Miller loam also occur in bottoms in association with other Miller soils.

These soils are all calcareous and are easily tilled.

These soils are very inextensive and occur only in narrow stream bottoms in the eastern part of the area. The principal areas mapped occur along Sweetwater Creek in Jones and Nolan Counties, and others too small to map occur in these counties and also in Taylor and Fisher Counties. These areas are flat or very slightly depressed, the sandy soils occurring in the higher positions and silt loam in the lower. These soils occur as lands which lie at elevations varying from 5 to 20 feet above the creek beds, and occasional overflows inundate the land for a few hours. These overflows do not interfere with cultivation as they are very rare during the growing season.

The abundant tree growth comprises elm, hackberry, mesquite, and other trees; there are also shrubs and some needle, grama, and other grasses.

Miller soils are extensively cultivated, probably 80 per cent being farmed. They are rather productive and well suited to all the crops of the region, and, because of the unusually favorable moisture conditions for upland soils, yields are good. Good tilth is easily maintained.

Corn is grown in small areas and yields from 20 to 40 bushels or more an acre, the higher yields being obtained in good seasons. Cotton yields range from one-third to one-half bale in dry seasons and about 1 bale an acre in very favorable years. Sorghum yields from 20 to 40 bushels of grain an acre and sorgo produces high yields of forage. Various other crops such as Sudan grass, alfalfa, fruits, berries, and vegetables would do well on these soils. Current values of this land range from $50 to $75 an acre.

MILLER SILTY CLAY LOAM

Miller silty clay loam is reddish-brown, heavy silty clay loam to a depth of about 8 inches and is underlain by dark chocolate-red stiff clay, which continues without change beyond the 3-foot depth. Both topsoil and subsoil are calcareous. When moist the topsoil is friable and the subsoil crumbly, but when dry both become rather hard where not cultivated.

Mapped areas include narrow strips of Miller clay loam and Miller fine sandy loam in which the subsoils are practically like those described above. The topsoil is coarser in texture and, in the fine sandy loams, it is somewhat lighter colored, being chocolate red or light chocolate red.

The topsoil of Miller silty clay loam is very plastic and sticky when wet, but cultivation is easy for the land breaks readily into small clods when plowed in either moist or dry condition, and shallow cultivation produces friable surface soil. According to chemical analyses this soil is well supplied with the elements of plant-food except nitrogen (*3*).

The total acreage of this soil in the west-central Texas area is small, as it occurs only in the narrow first bottoms of Elm, Bluff, Oak, and other creeks in Runnels and Taylor Counties. The largest body is near Abilene in northeastern Taylor County, and very small ones, too small to show on a reconnaissance map, occur in Jones, Fisher, Taylor, Nolan, Runnels, and Coke Counties.

The surface is flat, with a slight slope toward the streams. Some depressions representing old stream channels are found. Surface drainage is poor, owing to the nearly level surface, and subsurface drainage is slow on account of the heavy topsoil and subsoil. Overflows sometimes occur, but do not interfere with farming to any great extent.

Hackberry, elm, pecan, and mesquite are the principal trees on Miller silty clay loam, especially toward the lower reaches of the streams; and the undergrowth is chaparral and algerita. The grass vegetation include principally mesquite and buffalo grasses.

As the soil is very productive, approximately 80 per cent of the mapped area is used in the production of general farm crops, the remainder being devoted to pasturage. The soil is well adapted to the growth of cotton, corn, and milo, the chief crops, which with favorable rainfall produce good yields. Because of its heavy texture, the soil is only fairly retentive of moisture in dry seasons, but where well cultivated, the crops withstand dry weather very well. Cotton yields range from one-fourth to three-fourths bale an acre in good seasons, sorghum from 20 to 40 bushels, and corn from 15 to 25 bushels. In seasons of well-distributed rainfall two cuttings of Johnson grass are obtained, the yield ranging from 1 to 2 tons at each cutting. Some alfalfa has been grown in places, with good yields in years of ample rainfall. A small area of Miller fine sandy loam under irrigation, included on the map with Miller silty clay loam, is used with good results for the production of truck crops.

Miller silty clay loam rarely occurs in sufficiently large bodies to form entire farms, and therefore a selling price can not be given for it.

YAHOLA SOILS, UNDIFFERENTIATED

The principal soils included under Yahola soils are Yahola very fine sandy loam, Yahola clay loam, and Yahola silty clay loam. The first of these comprise by far the greater part of the comparatively small area mapped according to this classification. The heavier soils can be described in only a general way, as the materials of which they are composed are extremely variable.

The topsoil of Yahola very fine sandy loam is dark reddish-brown or reddish-brown, loose, friable very fine sandy loam, from 12 to 18 inches deep. This is usually underlain by subsoil of chocolate-red loamy very fine sand, also loose and friable. The entire soil is

calcareous, because of its friability retains water well under cultivation, and has good subsurface drainage.

The other Yahola soils consist of dark brownish-red clay loam or silty clay loam, underlain at depths varying from 4 to 18 inches by chocolate-red or light chocolate-red fine sandy loam or very fine sandy loam, which continues beyond the 3-foot depth. Both topsoil and subsoil are calcareous.

Included with Yahola soils as mapped are small areas of Miller soils, which differ from Yahola soils in that the subsoils are heavier than the surface soils.

Yahola soils, undifferentiated, occur in Concho, Runnels, Coke, and Mitchell Counties as narrow strips in first bottoms along Colorado River, where they are subject to overflow. Yahola very fine sandy loam generally lies at higher levels adjacent to terraces, but the other soils of this group are very much subject to overflow, as they are in the lowest positions immediately adjacent to rivers. These bottom-land strips are usually narrow and continuous along the stream.

The surface is nearly level, with a very slight slope toward streams. It is dissected in many places by streams crossing the bottoms, by old stream channels, and by isolated depressions which are remnants of old watercourses. Natural drainage is good.

In virgin condition these soils support a thick forest of elm, willow, hackberry, pecan, and mesquite trees, and a grass growth consisting chiefly of buffalo, mesquite, needle, and grama grasses.

The larger part of these soils is used for pasture land, less than 5 per cent being under cultivation. Cultivated areas are at the higher levels, as the likelihood of overflow constitutes the chief drawback to cultivation of these soils. The crops include cotton as the principal one, corn, grain sorghum, and such special crops as sweet potatoes, cantaloupes, and watermelons. In years of favorable moisture distribution cotton yields vary from one-fourth to one-half bale an acre, corn from 10 to 18 bushels, and sorghum from 15 to 20 bushels. Alfalfa does well in favorable seasons, and sweet potatoes, cantaloupes, watermelons, and vegetables produce excellent yields.

Yahola very fine sandy loam is well adapted to the production of blackberries, dewberries, and strawberries under irrigation, and vegetables also do well. The nut crop from native pecan trees along the streams adds considerably to the income of the landowners.

A small acreage of Yahola soils, undifferentiated, is irrigated by water pumped from Colorado River, whereby an appreciable increase in crop production is effected. Owing to the moisture-retaining capacity of the subsoils, the supply of water required in addition to the rainfall is small where frequent cultivation prevents loss of soil moisture.

FRIO SILTY CLAY LOAM

The topsoil of Frio silty clay loam, to a depth of about 12 inches, is dark brown or brown friable silty clay loam. The subsoil is brown friable silty clay loam or silty clay, the color of which, at depths ranging from 20 to 24 inches, is lighter brown or in most places yellowish brown. The topsoil contains sufficient organic matter to give some virgin areas a very dark brown color. When dry, the

immediate surface of cultivated fields is distinctly gray. The entire soil is calcareous, which in a large measure accounts for its friability. When wet, the soil is sticky and plastic; but if plowed when in the right moisture condition, the soil crumbles readily into small clods, favoring good tilth. The uncultivated soil forms a hard mass in dry weather.

As mapped, Frio silty clay loam includes small areas of Frio silt loam and Frio loam, which differ little from it except in texture. Frio soils occur in the first bottoms of all streams which have their headwaters in territory dominated by limestone formations. In many places these bottoms are too narrow to map on the reconnaissance scale and are included with adjacent upland soils. The largest areas of Frio silty clay loam are along Concho River and its tributaries in Tom Green and adjoining counties.

Frio soils occur mainly at two levels, on upper and lower first bottoms. The latter are inundated by almost every rise of the streams, whereas only the highest flood waters inundate the upper level. The principal overflows on these higher levels take place during late winter and early spring, and rarely after the middle of May. The bodies of this soil are nearly level with a slight slope toward streams. Old stream channels and depressions, which are probably remnants of old channels, occur on this land, and hog wallows are common in virgin soils. Drainage is fairly good because of the penetrability of the topsoil and subsoil, and because of the underlying layer of gravel which provides good subsurface drainage.

Hackberry, pecan, elm, and mesquite are the principal trees. Of these, the pecan trees, which grow along all the major streams and the lower parts of the smaller tributaries, are the most numerous and most valuable. Mesquite and buffalo grass are the principal grasses.

Frio silty clay loam comprises approximately 3 per cent of the total acreage of Tom Green County, 2 per cent of Concho County, and 1 per cent each of Runnels and Sterling Counties. A large part of the soil in the first three counties mentioned is under cultivation for general farm crops, but in Sterling County only 10 per cent is utilized for such crops the remainder being used for pasture land. The soil dries rapidly following overflow and because it is easily cultivated it is quickly prepared for plantings. The chief crops are cotton, corn, grain sorghum, and sorgo for forage, and there are extensive meadows of Johnson grass. Small grains which grow rank and lodge badly during wet years are rarely grown, since seeding time is in the fall and they are then subject to frequent overflows.

Under a system of dry-land farming, cotton yields vary from one-fourth to one-half bale an acre, corn from 15 to 25 bushels, and sorghum from 25 to 35 bushels in seasons of favorably distributed rainfall. In such seasons two cuttings of sorgo and Johnson grass can be obtained for forage, yields ranging from 1 to 3 tons at each cutting. In good years, two cuttings of alfalfa ranging from one-half to three-fourths ton each are obtained.

Irrigation of large areas along Concho River and its tributaries, Spring Creek and Dove Creek, has resulted in largely increased yields of crops. The soil is naturally highly productive, but it probably requires slightly more water and cultivation under irrigation than

do Yahola soils. Excellent results have been obtained in truck farming in the vicinity of Christoval in southern Tom Green County. Watermelons and cantaloupes thrive along Concho River east of San Angelo, and along Spring Creek. Owners of native pecan trees obtain considerable income from the sale of nuts. Plantings of paper-shell pecans on a commercial basis would probably prove profitable, especially under irrigation.

A very large part of this soil occurs on farms associated with other soils, but along the larger streams some farms are composed almost entirely of Frio silty clay loam. The current value of some of this land varies from $25 to $50 an acre, but where it is well improved and under irrigation the value is considerably higher.

SPUR SANDY SOILS, UNDIFFERENTIATED

These soils include the fine sandy loam, very fine sandy loam, loamy fine sand, and loam members of the Spur series. All these are of small extent, the fine sandy loam and very fine sandy loam members predominating.

The topsoil of Spur very fine sandy loam consists of chocolate-brown or dark reddish-brown very fine sandy loam about 10 inches deep, and the subsoil is loam or heavy very fine sandy loam material of the same color. When dry the immediate surface soil has a rather dark-gray color.

In long periods of dry weather both the topsoil and subsoil become very hard to depths of 3 feet or more, unless cultivated. Then the surface soil retains excellent tilth, although the subsurface layer becomes rather hard and is broken into small clods with some difficulty. The subsoil below a depth of 15 inches does not become so hard.

Spur sandy soils, undifferentiated, occur in the same general locations as Spur heavy soils. Areas of typical Spur very fine sandy loam lie along Clear Fork Creek near Roby, in Fisher County.

The surface is flat, and although the subsurface drainage is generally good, water may stand on the surface a short time after inundations. Poor surface drainage, however, does not interfere with successful cultivation of these soils, as overflows are infrequent and take place usually in early spring, and rarely during the growing season.

Small trees, mainly elm, hackberry, and mesquite, grow rather abundantly. The principal native grasses are needle, grama, and buffalo.

Probably 50 per cent of these soils is cultivated, as they have proved suitable for all crops of the region, principally cotton and sorghum, and are also resistant to dry weather conditions. Yields are approximately the same as on Spur heavy soils, undifferentiated. As a rule, crops on sandy soils withstand dry weather somewhat better than those on heavy soils. These soils tend to increase the value of farms on which they occur in good-sized fields; and the value of farms composed largely of these soils is as high as $75 an acre.

SPUR HEAVY SOILS, UNDIFFERENTIATED

Spur heavy soils, undifferentiated, include areas in which Spur clay loam predominates, with smaller associated bodies of the loam,

fine sandy loam, very fine sandy loam, and loamy fine sand members of the series.

Spur clay loam is dark-brown or chocolate-brown clay loam 6 to 10 inches deep, grading to a reddish-brown color below. In places the topsoil is rather silty and the subsoil is clay or silty clay. Spur loam resembles Spur clay loam in color but is slightly lighter in an air-dry condition. When Spur heavy soils are wet they are noticeably dark, when very dry they have an ash-colored cast on the immediate surface, and when moist the chocolate color is more pronounced. In cultivated fields the subsurface soil becomes hard during long periods of dry weather, whereas the soil remains crumbly because of the small moisture supply. The soil mass is calcareous throughout.

Areas of Spur heavy soils are inextensive on any one farm, as they occur in narrow stream valleys, but the total acreage is larger than that of the sandy soils. They are located mainly along small streams in Jones, Taylor, Nolan, Fisher, Scurry, and Mitchell Counties, but some are too small to be shown on the map.

This land is flat and lies from 10 to 20 feet above small streams. In a region of light rainfall the natural drainage is adequate for farming operations. Occasional overflows of short duration occur usually during early spring before crops are planted, but sometimes high water causes damage and makes replanting necessary.

The Spur heavy soils support a rather heavy growth of small trees, mainly hackberry, elm, chittam, mesquite, and some chaparral growth and other shrubs. Buffalo, needle, and grama grasses grow abundantly on virgin soil.

These soils are considered productive, and probably 70 per cent or more of the valley lands composed mainly of Spur heavy soils is under cultivation. The crops grown are cotton, sorghum, sorgo, and a small amount of corn. The soils withstand dry weather very well. Tilth is maintained without difficulty, and the subsoil in cultivated fields holds moisture remarkably well. In favorable seasons, cotton yields vary from one-half to three-fourths bale an acre, sorghum from 25 to 40 bushels, sorgo from 2 to 4 tons, and corn from 25 to 40 bushels. In very dry seasons yields are considerably lower, but the variations resulting from differences in moisture are less marked than on upland soils. Sudan grass and alfalfa make good yields.

Spur heavy soils, undifferentiated, rarely occur in areas of sufficient size to constitute entire farms. Farms including considerable acreage of these soils range in value from $35 to $60 an acre, and sometimes higher when in very favorable locations.

ARNO CLAY

Arno clay is dark chocolate-red clay to a depth of more than 36 inches. In places the clay below depths varying from 10 to 15 inches may be lighter red. In a few scattered areas the subsoil contains sufficient fine sand to give a fine sandy loam texture. The soil contains a high percentage of various salts more or less deleterious to plants. Very small areas of Arno very fine sandy loam were included with this type of soil as mapped.

Arno clay occurs in association with other alluvial soils in western and southern Ward and Loving Counties on narrow strips along Pecos River where it forms the boundary line of these counties.

The surface is flat and surface drainage is poor. Occasionally the land is flooded by Pecos River, but the rainfall is usually so light that the soil seldom has water standing on the surface.

The native vegetation consists of a fairly heavy growth of shrubs consisting of mesquite trees of small size, gray sage, narrow-leaf sage, and salt cedars, and a fairly heavy covering of grass, largely salt grass.

Very little of the soil is cultivated, and it is utilized mainly for pasture.

Alkali is present in this soil in large quantities just outside this area across the river in Reeves County, and doubtless the same is true of the soil in this area. Therefore crop production will be more or less problematical until all or a portion of the alkali has been removed. A very small acreage has been planted to alfalfa and cotton for several years near Porterville, Loving County, but results have been only partially successful owing to the accumulation of salts in the soil under irrigation.

Land values vary from $10 to $30 an acre.

PECOS CLAY

The topsoil of Pecos clay is dark-brown or nearly black clay, from 20 to 24 inches deep, which when dry is much lighter in color, being gray or grayish brown. The subsoil to a depth of 36 or more inches is chocolate-red clay. The soil is very sticky and plastic when wet, and hard though crumbly when dry. Numerous gypsum crystals occur throughout the topsoil and subsoil, and both are calcareous.

Included with Pecos clay as mapped are small areas of Petrole silty clay and some Pecos silty clay loam. Petrole soils have ash-colored clay topsoils, underlain by subsoils that are gray, with yellow and rust-colored mottlings, and at a depth of 20 inches the color is chocolate-red. The soil represents chalky material washed onto the Arno soils.

Pecos clay is of small extent in the area, occuring as a narrow strip along Pecos River in southern Ward and Crane Counties, in the western part.

Owing to the flatness of the land, both surface and subsurface drainage are poor and the water table is near the surface. The soil is occasionally inundated by overflow water from Pecos River.

This land is not cultivated but is utilized for pasture. The native vegetation consists principally of salt grass, small mesquite trees, and some narrow-leaf sage. As the soil is heavy, it crusts and packs badly at the surface, making planting and cultivation difficult. Alkali has accumulated in such quantities in places that crops can not grow, but with a good system of flooding and draining to remove excess salts, this soil should produce excellent yields of cotton, alfalfa, and various other crops.

Unimproved land of this type is valued at prices ranging from $10 to $25 an acre, and improved land under irrigation from $50 to $75 an acre.

DUNESAND

Dry, virgin dunesand consists of a very fragile crust one-eighth inch thick; a layer of loose, yellowish-gray fine sand to depths varying from 2 to 4 inches; a layer of grayish-yellow compact fine sand to

depths of about 12 inches; a layer of very pale yellow sand to depths of more than 6 feet in most places; underlain by white, soft, highly calcareous caliche, between depths of about 4 and 20 feet, according to the depth of wind-blown sand. When the soil is wet or moist it is very loose. The material shows no effervescence with hydrochloric acid within a depth of 3 feet.

Dunesand occurs in a large tract in the southwestern part of the surveyed area. It forms a solid strip of country from 10 to 20 miles wide, extending in a general southeasterly direction from the southeast corner of New Mexico through southwestern Andrews, eastern Winkler, southwestern Ector, and northern Crane Counties. This is true dune sand, subject to blowing and consequent changes in the surface configuration of many patches throughout its extent. Much of it, however, is fixed or temporarily fixed by vegetation, and as a whole it is shifting very slowly. The dunes are conspicuous features of the landscape, the light-colored patches, bare of vegetation, causing them to stand out prominently.

The surface of areas of dunesand is decidedly hummocky or billowy. The dunes rise from 5 to 20 feet above the intervening depressions, which lie at or near the base level of the plain. They are numerous, in places covering more than 50 per cent of the surface. Drainage is thorough for the most part, although in the depressions water may stand for some time after rains. The subsurface drainage is usually rapid. An abundance of good water is obtained from wells from 30 to 75 feet deep.

The native vegetation consists of shin oak, yucca (bear grass or soap weed), various weeds, and a very scant growth of coarse grasses, including needle grass. Grasses grow chiefly in the depressions. As the loose sand drifts about in every hard wind, some of the dunes are bare of vegetation or have only a scant growth of shin oak. Sand bur grass and sagebrush are abundant in places, also a beautifully flowered weed (*Heliotropium convolvulaceum*, Nott).

This soil is utilized exclusively for grazing and no attempt is made to cultivate it. The land supports from 15 to 20 head of cattle to the section, and if not overstocked is considered good grazing land as the vegetation is always rather abundant, regardless of seasonal variations. In addition to the native grasses the cattle eat the shin oak shrubbery, bear grass, and various weeds, the most valuable being mustard. Although shin oak is a valuable forage plant, it is considered unsafe for cattle to eat during early spring when the new buds and leaves are coming out, and wherever possible, ranchers take the cattle off the "shinnery" pasture during April. Dunesand occurs on large ranches, and if sold separately would probably bring from $2 to $5 an acre in large tracts. Ranchers pay from 8 to 10 cents an acre by the year when leasing the land.

ROUGH STONY LAND

The term "rough stony land" is used to designate a physiographic condition rather than a soil type. It includes the steeper, more precipitous hills and slopes and outcropping limestone ledges covered with large and small rock, chiefly remnants of overlying hard limestones. The interstitial material varies in color from yellowish brown to dark brown, though the rocks are so abundant in places and the

slopes so steep that very little soil material has accumulated. Where softer white limestone and marl come to the surface the soil material is light colored and belongs to the Brackett series; otherwise it belongs to the Valera series. The soil material varies in texture from clay to loam and is generally granular, owing to the presence of minute rock particles and lime aggregates. The fine earth material is calcareous. Where the classification includes hilly areas, narrow strips of Valera stony clay or Valera clay occur on narrow divides and outcropping ledges. Small areas of rough stony land are included in Valera stony clay as mapped, on account of their narrowness and discontinuity, but where they are prominent they are indicated by rock outcrop symbols.

Areas of rough stony land have been mapped in Runnels, Coke, Tom Green, Howard, Mitchell, Irion, Sterling, Nolan, Upton, Crane, and Taylor Counties. The largest area is in the extreme southern part of the Colorado River Valley in Coke County. Ketchum Mountains and the range of hills west of Mertzon constitute the chief area of rough stony land in Irion County. The large area in Sterling County lies in the northeast in the "breaks" from the upland to the old Colorado basin.

Rough stony land in the area surveyed is the result of the erosion of Edwards Plateau, which exposed the underlying limestones. After the hard limestone was cut through, erosion of the underlying softer material was rapid. As the protective covering of hard rock was undermined by erosion and dissolution of the soft limestone, huge blocks and bowlders from the upper formation broke off by their own weight, some remaining on the slopes, others rolling to the bottom of the valleys.

Rough stony land includes rough and hilly areas, steep slopes, and canyon walls. The divides are generally narrow, the slopes from the plateau to the valleys are sharp and precipitous, and the valleys are deeply cut. In areas adjacent to the old Colorado River basin, in southern Coke County, the distance from the drainage heads to the old valley is generally short and the elevation of the plateau above the valley floor is great, varying from 300 to 600 feet.

The native vegetation varies somewhat with location. In Irion County the land is for the most part barren of shrubbery, though here and there is a sparse growth of live oak, mesquite, and some cedar. Farther east, shin oak (*Quercus breviloba*) and cedar (juniper) are common growths on the steep slopes. Live oak and mesquite trees grow on the divides and less steep areas, and redbud (*Cercis occidentalis*) grows extensively on the steep slopes in Nolan and Coke Counties. Mesquite and buffalo are the chief grasses, though needle grass is abundant in some places. Weeds grow profusely and chaparral growth, algerita, cat-claw, yucca, and other native shrubs are common.

Rough stony land is valued for pasture land only, but it is of less value for grazing purposes than other soils, as grasses obtain a foot-hold with difficulty. As grasses are less abundant than other vegetation, the land is better suited for pasturing sheep and goats than cattle. Current values of this land, when sold with the surrounding soils, vary from $3 to $10 an acre.

ROUGH BROKEN LAND

Areas mapped as rough broken land include a large variety of soils. The fine earth material ranges in texture from fine sand to clay, these areas being so intimately associated that it was impracticable to map each one separately. This land is characterized by its rough, rugged surface, and differs from rough stony land in that it is comparatively free from stones. It includes small mesas having steep, rough slopes; escarpments along the edges of Llano Estacado, Edwards Plateau, and other distinct elevations; and areas along drainage ways where erosion has taken place to such an extent as to render the land unfit for cultivation.

Here and there small bodies of arable land are included with this soil as mapped, which on account of their isolated positions will probably never be cultivated. These form narrow strips of bottom land along some of the larger streams, some of the more gentle slopes, level or nearly level surfaces of small mesas, and other small areas totally or almost surrounded by rough, nonarable land. In some locations, cherty gravel is abundant on the surface and some is present throughout the topsoil to a depth of about 10 inches.

Scattered areas of rough broken land occur throughout Rolling Prairies and Edwards Plateau, as well as along the outer margins of High Plains, where erosion is more recent, and along the larger drainage ways, especially those with numerous tributaries. No large tracts of rough broken land occur in the surveyed area, but several small bodies were mapped in Nolan, Scurry, Fisher, Mitchell, Howard, and Borden Counties. Small areas of broken, eroded land were mapped with the various soil types, but their surface condition is indicated by parallel diagonal crosslines, denoting moderately rough and broken land.

The native vegetation varies somewhat with the texture of the soil. The heavier soils usually support a growth of chaparral, mesquite trees, and cedar. The most common grasses are needle, tobosa, wire, grama, buffalo, some curly mesquite, and *Triodia pilosa*. On lighter-textured soils mesquite trees, yucca, and cat's-claw grow, and the most common grasses are needle and buffalo. On steeper and more eroded areas vegetation is scant, but on fairly level surfaces the grass is very luxuriant when the rains are seasonable. On account of excessive drainage, however, this land is inclined to be droughty, and in seasons of low rainfall the grass becomes parched and furnishes scant pasturage. Shin oak grows in places, and weeds are abundant on this soil.

This land in the west-central Texas area is used entirely for pasturing livestock. The number of cattle supported on a section of this land ranges from 15 to 30, depending on the grass growth, which varies with the rainfall. On some of the rougher areas sheep and goats are pastured, the land supporting from 70 to 100 head to the section.

The selling price of this land ranges from $3 to $12 an acre, depending largely on the degree of roughness. Some areas, when sold with less rugged surrounding land, bring about $20 an acre.

None of this land is under cultivation, but a few small, isolated, cultivable areas of bottom land could be used for growing forage crops. Sweet clover also might be introduced both on the hills and

in the valleys, and would be a valuable addition to the present grazing plants.

LAND UTILIZATION

In the following tables are summarized the utilization and adaptation of the soils of the region and their physical characteristics.

Soils groups of the west-central Texas area, showing their drought resistance, present utilization, and adaptation

Soil group	Type of soil	Drought resistance	Present utilization	Adaptation
1	Rough stony land, rough broken land, Valera stony clay, Reagan gravelly silty clay loam, Ector gravelly loam, Reeves gravelly loam, Amarillo loam, shallow phase, Abilene clay loam, shallow phase, Valera clay.	Poor	Grazing	Grass and shrubs.
2	Dunesand	Fair	do	Do.
3	Amarillo loamy fine sand, Miles fine sand.	do	do	Vegetables, fruit, grass.
4	Richfield loamy fine sand	do	do	Grass, cotton, sorghum.
5	Amarillo fine sandy loam, light phase, Miles fine sand, shallow phase, Miles fine sandy loam.	Good	Grazing and some farming.	Cotton, corn, sorghum, forage, vegetables, fruit.
6	Amarillo fine sandy loam, Miles fine sandy loam.	Very good	Grazing and farming.	Cotton, sorghum, forage, fruits, vegetables.
7	Miles fine sandy loam, rolling phase.	Fair	do	Same as 6.
8	Vernon very fine sandy loam	do	Farming	Do.
9	Amarillo clay loam, Miles clay loam.	do	do	Cotton, sorghum, forage, wheat, oats.
10	Miles clay loam, rolling phase	Very poor	Grazing	Grass, wheat, oats.
11	Vernon clay, Vernon clay loam	Poor	do	Grass and shrubs.
12	Abilene clay loam, Abilene silty clay loam, Roscoe clay.	Good	Farming and grazing.	Cotton, sorghum, forage, wheat, oats.
13	Valera clay	Fair	do	Cotton, sorghum, forage, wheat, oats, grass.
14	Reagan silty clay loam	do	Grazing	Same as 13.

Characteristics of virgin soils to a depth of 3 feet

Group	Wet condition	Moist condition	Air-dry condition
1			
2	Slightly coherent	Slightly coherent	Surface somewhat crusted; loose below.
3	Very slightly coherent	Incoherent	Surface somewhat crusted, 1 or 2 inches deep; subsurface loose, from 2 to 8 inches deep; subsoil hard, crushes readily, from 8 to 36 inches deep.
4	do	Slightly coherent	Do.
5	Slightly coherent	do	Loose in surface few inches; hard down to clay; clay very hard; crushes with difficulty to large clods.
6	Soil slightly coherent; subsoil sticky.	Surface friable and slightly coherent; subsoil crumbly.	Surface loose to a depth of 4 inches; subsurface very hard medium clods; upper subsoil very hard, large clods; moderately hard subsoil clods.
7	do	do	Same as 6, with caliche beneath.
8	do	do	Surface loose, subsurface hard clods; upper subsoil very hard, large clods; lower subsoil very hard, small clods.
9	Soil slightly sticky; subsoil very sticky.	Soil mellow to unctuous; subsoil crumbly.	Surface inch granular; subsurface hard, fine clods; upper subsoil very hard, large clods; lower subsoil hard, medium clods.
10	do	do	Same as 8, with caliche beneath.
11	do	do	Soil very hard large clods; subsoil, very hard, large clods.
12	do	do	Surface inch or two granular; subsurface loosely bound mass of very hard clods; upper subsoil strongly bound mass of very hard large clods; lower subsoil loosely bound mass of moderately hard clods of medium size.
13	do	do	Do.
14	Sticky	Mellow	Surface and subsoil both hard, crushing easily to mass of fine and small clods.

IRRIGATION

The rainfall of this area ranges from about 19 inches in the eastern counties to about 11 inches in the western part. The higher rainfall is adequate for a variety of crops and the need for irrigation is not so pressing as in districts receiving less rain. However in many years, the annual rainfall in the northern part has been too small to insure profitable yields of crops and some attention has been given to the utilization of the stream flows for irrigation purposes. Water was first diverted for irrigation before the Civil War from South Concho River, near San Angelo, and was utilized upon adjacent bottom lands for irrigation of gardens and small fields. This was followed by the construction of a number of diversion dams upon other streams, and of several miles of canals. In 1909 about 8,000 acres were under irrigation in Irion, Runnels, and Tom Green Counties, and no data was available concerning the extent of irrigation in the other eastern counties. Irrigation is now practiced to some extent in Tom Green, Irion, Runnels, Concho, Sterling, and Coke Counties from Concho and Colorado Rivers and some of their tributaries, the 1920 census reporting more than 10,000 acres being irrigated in these counties in 1919.

The practice of irrigation developed somewhat later in the western part of the area on account of the much later settlement there, but the acreage under irrigation increased far more rapidly, and in 1909 there were over 16,000 acres of irrigated land in Loving and Ward Counties. No statistics were available for the remaining counties. Pecos River is the only source of surface water for irrigation in this western part, and water is diverted from it by low dams constructed across the channel of the stream near Barstow and Grandfalls. The normal flow of the stream is entirely utilized for irrigation and any increase in the irrigated area is dependent upon the construction of storage reservoirs to hold flood waters. In years of abnormally low discharge, the river water is insufficient for the acreage which is covered by the canals.

No record of any acreage in the Pecos Valley that is irrigated by water pumped from wells exists. In the northern and eastern parts of the area, however, irrigation of small tracts by pumping from wells is of considerable economic importance. Irrigation of field crops by pumping is rarely practiced on account of the cost of the necessarily high lift. The use of well water for irrigation is generally restricted to gardens and small orchards and is the means of supplying fresh fruits and vegetables to a large proportion of the farms and ranches, particularly in the western part of the area.

In the eastern part, the irrigated lands are mainly recent-alluvial first-bottom soils. The lower elevations of some older stream terraces are occasionally supplied with water. The heavy soils of the Frio and Abilene series and the lighter-textured soils of the Yahola and Miles series, are more commonly irrigated. In the western part, irrigation is confined almost wholly to areas of Reeves fine sandy loam.

In the eastern irrigated districts, the quality of the irrigation water is excellent. The waters of Pecos River, however, carry large quantities of dissolved salts, and at Barstow the proportion in the

river water has at times been found to be as high as 380 parts per 100,000. This is a very unsatisfactory condition, and the continued use of such water calls for special care in maintaining very adequate drainage facilities for the irrigated lands. This situation has been met in the vicinity of Barstow, where a system of deep open drains has reduced the supply of alkali in the soil.

Practically all the crops are grown in the irrigated districts. The yields obtained upon irrigated land are about double the average yields on nonirrigated land of the same character where dry farming is practiced.

Up to the present (1922) no attempt has been made to conserve the flood waters in the stream. The normal stream flows are fully utilized and any marked increase in the irrigated area can only be obtained by the construction of storage reservoirs at different points along the streams, and by the use of stored water during summer. Many large tracts of productive soils throughout the west-central Texas area could be utilized for the production of crops under irrigation, but some of these, particularly in the western part, can not be cultivated successfully until this is done. Much of the land in the eastern part also would yield much greater returns if irrigated.

ALKALI

The term "alkali" as used throughout the west-central Texas area applies to almost any whitish substance which occurs as a layer on the surface of the soil. Many farmers attribute to alkali deficient plant growth or poor crop production which may be the result of some plant disease, poor moisture conditions, or an unfavorable physical condition of the soil. The soil in many parts is underlain by large quantities of limy material, usually soft chalky marl or calcium carbonate, and in the southwestern part by beds and layers of gypsum, or calcium sulphate. The last two subsances are practically insouble in water and do not constitute alkali. They are not deleterious to plant growth, except in places where so abundant as to displace true soil material which contains plant food. Areas on slopes and beds where gypsum or calcium sulphate is very abundant, are easily recognized by the thin covering of soil material and scant vegetation.

The term "alkali" refers to soluble salts in soil or water which hinder or prevent plant growth. Black alkali does not appear to any appreciable extent in either the soils or irrigation water. The alkali salts are largely made up of sodium chloride, and the sulphates of sodium, magnesium, and calcium are present in large quantities.

Only small areas of soils in west-central Texas are affected by deleterious salts. These occur along Pecos River and are mostly alluvial soils formed by the deposition of sediments from the flood waters of that stream.

The heavy soils are more susceptible to the accumulation of salts than the lighter soils, as they naturally have less effective subsurface drainage, and at the same time the fine texture encourages more rapid evaporation of soil water from the surface. The best method of

preventing the accumulation of salts is some form of drainage, preferably subsurface drainage, which will remove them from the soil. At Barstow and Grandfalls the soils under cultivation are irrigated from Pecos River, and the salts are brought in and left in the soil by the irrigation water. At these places, the soils are sandy and the tendency toward accumulation of alkali is not so great as it is on the lower and heavier soils along the river.

The following figures show the increase of salt in Pecos River water, in parts per 100,000, as it flows down the valley: Hagerman, N. Mex., 202; Barstow, Tex. (intake), 390; and opposite Pecos, Tex., below all irrigation, 525 parts.

These figures indicate that in irrigating land from Pecos River, a good system of drainage should be provided. Otherwise, there will be a heavy accumulation of salts in the soil which will prove to be deleterious to plant growth, especially in seasons of low rainfall when the river is low.

SUMMARY

The west-central Texas reconnaissance survey includes 27 counties in the west-central part of the State. The area consists of rolling prairies in the northeast, eroded, and rather rough dissected plateaus in the southeast, and high, nearly level plains in the west. Some rather rough and stony lands occur in the southeast, and a narrow belt of rough and broken escarpment extends through some of the north-central counties. The highest altitudes are about 3,500 feet in the northwestern counties, and the lowest are somewhat less than 2,000 feet above sea level on the eastern edge of the area.

The country is well settled in the northeast, fairly well settled in the southeast, and sparsely settled in the west. Settlement is usually thickest near railroads.

The climate is mild and healthful. The average annual precipitation at Abilene in the northeast is 24.8 inches; at Knickerbocker in the southeast, 19.46 inches; and at Barstow in the extreme west, 11.1 inches. These figures show a wide range in precipitation in an area which lies definitely within the semiarid region. The rainfall varies considerably from year to year, and even in the east and northeast, in many years when crop yields are scant because of insufficient rainfall, complete crop failures are rare. The extreme southwestern part is usually too dry for the production of crops by dry-farming methods. As a rule the heaviest precipitation is during spring and summer. The mean annual temperature at Abilene is 63° F.

A large number of types of soils occur in the area. They are derived from the weathering of Permian, Triassic, Cretaceous, Tertiary, and Quaternary deposits. Many small areas of recent-alluvial soils are mapped. Most of the soils on Edwards Plateau have been classed as members of the Valera and Reagan series; on the High Plains, members of the Amarillo series; and those on the Rolling Prairies, as members of the Miles, Abilene, and Vernon series.

Most of the soils are rather fertile and are suited to the production of a considerable number of crops, yields being determined to a large extent by the supply of moisture. There are large areas of heavy

soils, principally of clay loam texture, and small areas of clay and loam. These soils are well suited to cotton, sorghum, forage crops, small grains, and in some places to corn. Yields vary with the surface configuration of the heavy soil lands to a considerable extent, for where the land is flat they collect considerable more rain water than where it is sloping. If a good supply of water has been stored in the soil during winter or early spring, crops will be produced in the subsequent growing season with a minimum rainfall. Sandy soils with heavy clay subsoils also withstand dry weather conditions remarkably well and are suited to most of the crops mentioned, except small grains. They also are well suited to the production of melons, berries, vegetables, and fruits. Sandy soils absorb more rain water than the heavy soils, except on the very flat areas.

Lighter-textured and deep sandy soils are especially suited to the production of vegetables, berries, and fruits, and will produce fair yields of forage, cotton, and grain sorghums. As they are susceptible to drifting in spring winds, the shallow soils and dunesand are of little value for farming and are best suited to grazing.

A very large acreage of land in the eastern part of the area is utilized for general farming, though there are also some ranches; but most of the western half is still used for ranching. Livestock farming is practiced with good results on some smaller farms, but most of it is done on large ranches. Cattle are raised principally, but some sheep and goats are also raised and run on ranches mainly on the rougher land in the southeastern part.

A gradual trend toward farming is taking place in the western part, and ranch lands are constantly being opened up and devoted to farming.

The principal crops are cotton, milo, kafir, feterita, and sorgo. Wheat, oats, corn, Sudan grass, Johnson grass, and various other crops are grown to a smaller extent, and in the irrigated districts much alfalfa, cotton, corn, and grain sorghum. Cotton and grain sorghum seem to withstand dry weather better than other crops under dry farming. Vegetables and fruits are grown for home use on most farms.

Comparatively little land is farmed under irrigation, though where this is practiced in the southeastern part of the area along Concho and Colorado Rivers and some of their tributaries, and in the extreme west in two places along Pecos River, good results are obtained. Many farmers irrigate small gardens and orchards from wells by use of windmill pumps. No alkali is present in the soils except in the extreme southwest in land under irrigation. This condition may be remedied by proper drainage.

The current value of the rough and stony land varies from $6 to $20 an acre, and of the most highly improved farm lands from $60 to $75. Ordinarily the current value of improved farm land ranges from $25 to $50 an acre. Raw ranch lands, comprising good soils in the most favorable western parts, can probably be bought at prices varying from $15 to $25 an acre.

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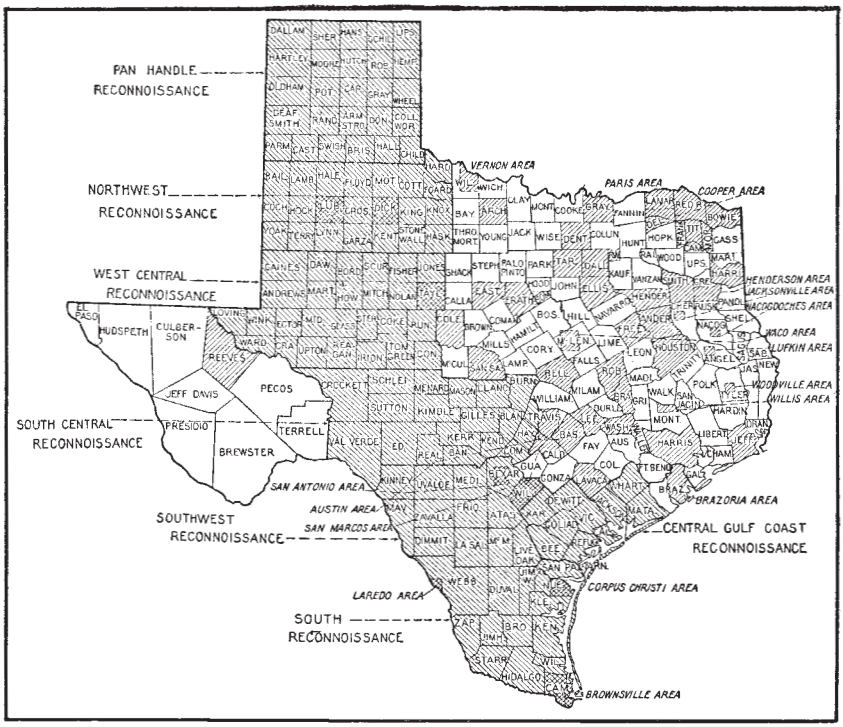

Areas surveyed in Texas, shown by shading

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