

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE TEXAS AGRICULTURAL EXPERIMENT STATION,
B. YOUNGBLOOD, DIRECTOR.

RECONNOISSANCE SOIL SURVEY OF NORTHWEST TEXAS.

BY

WILLIAM T. CARTER, JR., IN CHARGE, H. V. GEIB, M. W. BECK
AND A. C. ANDERSON, OF THE U. S. DEPARTMENT OF AGRICULTURE,
AND T. M. BUSHNELL, J. F. STROUD,
W. B. FRANCIS, AND NEAL GEARREALD, OF
THE TEXAS AGRICULTURAL EXPERIMENT STATION.

HUGH H. BENNETT, INSPECTOR, SOUTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1919.]



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., September 9, 1921.

SIR: I have the honor to transmit herewith the manuscript report and map covering the reconnoissance soil survey of Northwest Texas, and to recommend that they be published as advance sheets of Field Operations of the Bureau of Soils, 1919, as authorized by law. This work was done in cooperation with the Texas Agricultural Experiment Station.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

HON. H. C. WALLACE,
Secretary of Agriculture.

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FIGURE.

Fig. 1.—Sketch map showing location of the Northwest Texas Reconnaissance area	1
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MAP.

Soil map, reconnaissance survey, Northwest Texas sheet.

RECONNOISSANCE SOIL SURVEY OF NORTHWEST TEXAS.

By WILLIAM T. CARTER, Jr., In Charge, H. V. GEIB, M. W. BECK, and A. C. ANDERSON, of the U. S. Department of Agriculture, and T. M. BUSHNELL, J. F. STROUD, W. B. FRANCIS, and NEAL GEARREALD, of the Texas Agricultural Experiment Station.—Area Inspected by HUGH H. BENNETT.

GENERAL DESCRIPTION OF THE AREA.

LOCATION AND EXTENT.

The area surveyed includes three tiers of counties in northwest Texas, just south of the Panhandle region of the State, of which a reconnoissance survey has previously been made. It extends eastward from the New Mexico line across seven counties and includes 22 counties, comprising an area of 19,404 square miles. These are Bailey, Cochran, Cottle, Crosby, Dickens, Floyd, Foard, Garza, Hale, Hardeman, Haskell, Hockley, Kent, King, Knox, Lamb, Lynn, Lubbock, Motley, Stonewall, Terry, and Yoakum. Of these Lubbock County has been covered by a detailed soil survey, made in 1917. The area covered by this reconnoissance is rectangular, having a length of 206 miles east and west and a width of about 93 miles north and south. The area is bounded on the north by the counties of the Texas Panhandle and Oklahoma, on the east and south by other Texas counties, and on the west by New Mexico. It lies within the semiarid region of the Great Plains.

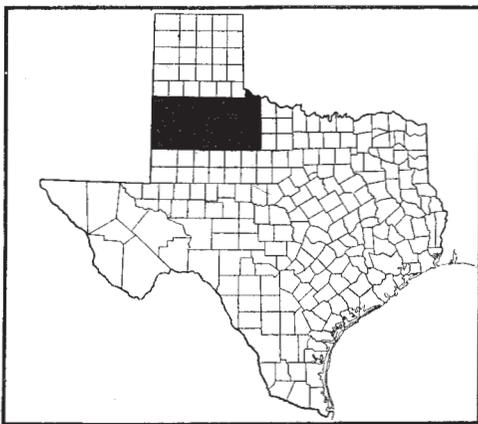


FIG. 1.—Sketch map showing location of the Northwest Texas Reconnoissance area.

The base maps used in making this survey consisted principally of official county maps compiled by the Texas General Land Office. Recent features, such as new towns and railroads, were added, and positions were located by the use of the plane table.

Only the main soils are shown on the map, as the many small areas and slight variations in the soils could not be shown on a map of the scale used in reconnoissance work. The object of the work has been to construct a map showing the principal soils and to bring together the most important data concerning the agricultural resources of the region as related to soil conditions.

SURFACE FEATURES.

The Northwest Texas area lies in the southern part of the Great Plains region of the United States, a region that extends several hundred miles eastward from the foothills of the Rocky Mountains and reaches from Canada southward nearly to the Gulf. There are many varieties of country and different types of topography in this great region, but in general its surface is flat and smooth to rolling, with some rough or hilly lands in places, due to erosion. The country is treeless and is known as the Plains.

In the Northwest Texas area there is a general slope to the southeast. The highest land is in the northwestern part of the area, where the elevation above sea level is approximately 3,500 feet, and the lowest is in the eastern part, where it is in places something less than 1,500 feet. The area consists of two distinct physiographic regions. The western part is a high, nearly level to undulating, smooth plain, bordered on the east by an escarpment of rough land which leads down to the rolling prairies, or plains, which occupy the eastern part of the area. These prairies are more or less eroded and broken in places near the larger drainage ways. The drainage ways are numerous in the rolling prairies, but the streams in practically all of them are intermittent, ceasing to flow in dry seasons. The main streams, which are the headwaters of some of the large Texas rivers, reach far back into and across the High Plains, occupying narrow and shallow valleys. These streams also are of intermittent flow.

Approximately the western half of the area is occupied by the High Plains and the eastern half by the rolling low plains.

High Plains.—The High Plains occupy one main body in this area. This is a part of the main body of the Llano Estacado, or Staked Plains, locally referred to as the South Plains, as it lies within the southern half of the Texas High Plains region.

The High Plains here consists of a high, nearly level plain with a range in altitude above sea level of about 3,000 to 3,500 feet. To the eye the surface appears in perspective to be practically dead level; in reality the greater part is gently undulating. In some small areas in the western part, where the sandy soils have been blown into ridges or small dunes, the surface is billowy. The eastern margin of the High Plains is definitely marked by a rather pre-

cipitous slope or escarpment of broken and eroded land leading down to the rolling low plains several hundred feet below. Erosion has produced this rough land by cutting away the High Plain along its eastern edge. Numerous small streams have their origin in the edge of the High Plains, while some of the larger streams reach far back into this section, making its eroded margin therefore very irregular in outline. The surface of the High Plains back from the eroded edges is seemingly unaffected by erosion in the narrow canyons, the unbroken land extending almost up to the brink of the canyon walls.

In the northeastern part of the High Plains of this area, where the surface soils are comparatively heavy, there are many small depressions or lake beds. These lie from 2 or 3 feet to as much as 25 feet below the level of the plain, and range in size from a few acres to 50 acres or more. These are locally termed "playa lakes," or "playas." These lakes often remain dry for several years, containing water only during seasons of heavy rainfall. They may have been formed by the sinking of the surface or by local removal of soil material by wind. In the southern and western parts of the High Plains section, where the soils are of a comparatively light texture, there are fewer of these small lakes. However, in this section there are a number of so-called salt lakes which are dry most of the time, the surface being covered with an incrustation of whitish crystalline salts. These lakes lie from 50 to 150 feet below the general surface of the High Plains, inside a rolling but generally sloping area of a mile or more.

A few shallow streams or draws extend across the High Plains in a southeasterly direction, forming creeks which are the headwaters of streams that become more important farther east. The principal draws are the Running Water Draw (White River), Double Mountain Fork of Brazos River, Lost Draw, and Sulphur Draw Fork of the Colorado River. In the upper parts of these streams the channels are very indefinitely marked or consist of a series of connected low swales. As they increase in size in the downstream direction the valleys deepen and develop into definite channels. Near the border of the High Plains they become canyons which widen and deepen rapidly as they approach the eroded or low plains.

The two main canyons of the area are the Blanco and Yellowhouse Canyons, which extend for many miles into the interior of the plains. These streams have no small tributaries, and only a very small percentage of the rainfall drains into them. Some of the salt lakes receive the drainage water of contiguous territory through short winding draws.

Eroded or low plains.—The High Plains doubtless at one time extended eastward over the entire area covered by this survey. The

eastern part of the High Plains was cut down by the gradual advancement of lateral erosion and the material carried away by streams. This process exposed the underlying rocks and formed the present eroded plains or low plains. The country consists of prairie plains, varying in topography from gently undulating to rolling and hilly, in marked contrast to that of the smooth High Plains. The surface is crossed by a number of good-sized streams whose tributaries reach back into all parts of the upland. The surface ranges from hilly or broken near the streams to smooth and gently undulating over the interstream areas or divides in which the smaller streams head. Several small buttes or mesas, representing islands—isolated remnants of the original High Plains that have not yet been effaced by erosion—stand from 100 to 200 feet above the surface of the surrounding country. In the eastern part of the area, where the Permian Red Beds are exposed, there are large bodies of land having a surface that at some distance appears to be smoothly rolling, but on closer examination these areas are found to be dissected by numerous draws and steep-walled gullies which make them too rough for cultivation, except for a few acres here and there. This eroded and gullied condition is gradually encroaching on the smoother lands in many places.

The Breaks.—Included under the term of “breaks” is a band of broken, rough country along the border of the High Plains (including the escarpment), as well as rough areas along streams in other sections. The areas along the High Plains escarpment are often precipitous, but in a few places the slope is more gradual. Near the upper part of the escarpment the calcareous substratum underlying the High Plains has hardened into rock locally called cap rock. This hard material prevents the wearing away of the High Plains surface until the cap rock is undermined by lateral erosion and breaks off, after which the softer material is cut away more rapidly.

This escarpment is visible for many miles from the east, rising several hundred feet above the rolling prairies, and its white bare slopes and bluffs form a conspicuous feature of the landscape. It varies from one-half mile to several miles in width. The lower slopes are not as steep, but they have been eroded so badly that they have a rough or “badlands” character. A sparse growth of juniper and shrubs occurs here, with both short and bunch grass, but much of the surface is bare of vegetation. The escarpment extends through the central part of the area in a general north-and-south direction, though in a very irregular and wavy line. Its walls reach back along the canyons in narrow strips into the High Plains. Other areas of eroded lands, rough and broken, occur farther east along the larger streams in the low plains.

Stream valleys and canyons.—In the western part of the area on the High Plains the small streams (the headwaters of the larger streams

in the eastern part of the area) have shallow, narrow valleys which gradually become deeper and wider as they approach the escarpment and finally develop into canyons. The two main canyons in the High Plains are the Yellowhouse Canyon, in which the Double Mountain Fork of the Brazos River runs, and the Blanco Canyon, through which the headwaters of the Salt Fork of the Brazos flow. These canyons extend back 20 or 30 miles into the High Plains. They are 200 to 300 feet deep near the escarpment or edge of the High Plains and range from one-fourth mile to 2 miles in width. The walls are steep, although as the canyons widen there are more sloping areas reaching from the first bluffs to the bottom.

The streams of the eastern part of the area have wide beds and very narrow valleys. The channels are sandy stretches one-eighth to one-half mile wide, with only narrow fringes of valley lands adjacent. The channels often adjoin the flanking bluffs.

On the map accompanying this report parallel ruled lines indicate areas of land within soil types that are so rolling or hilly or eroded as to make cultivation of large parts of such areas difficult. Land too rough to cultivate and best suited for grazing is shown by separate color as Rough broken land.

Regional drainage.—In the High Plains there is very little run-off, owing to the nearly level surface. A little surface water runs into the small lake beds and a little into the few drainage depressions, draws, and canyons. Most of the rain water is absorbed at once by the soil or collects in the slight depressions, where a part of it gradually sinks into the soil and a part is removed by evaporation. The more numerous streams crossing the eroded or low plains with their tributaries give adequate drainage to all parts of this eastern section of the area. Here there are many places adjacent to the streams where surface drainage has been too rapid, with the result that erosion has made considerable areas of land unfit for cultivation. Owing to the porous nature of the very sandy soils the rain water is absorbed to a large degree, and few or no stream channels have been formed in such sandy lands.

The Northwest Texas area is drained by three principal river systems: the northeastern part by the Red River system, the southwestern part by the Colorado River system, and the remainder by the Brazos River system. Probably more than two-thirds of the area is drained by the headwaters of the Brazos River. In general, the drainage of the western part of the High Plains is southeasterly, but when the streams reach the lower eroded plains they flow in a general easterly direction.

The Red River system drains all or parts of eight counties in the northeastern corner of the area. The streams of this system are the Pease River, the North and South Forks of the Wichita River, together with their numerous small tributaries, which form a net-

work of drainage ways. The Prairie Dog Town Fork of the Red River borders and drains part of one county in the extreme north-eastern part of the area. These streams have their origin in the eastern edge of the High Plains and flow in a general easterly direction.

The main part of the Northwest Texas area is drained by the Brazos River system, whose principal streams are Salt Fork and Double Mountain Fork. These streams rise in the western part and extend across the High Plains in a southeasterly direction. They begin as narrow draws, gradually widening and deepening, and have but few tributaries. When they reach the eroded or low plains they flow in a more general easterly direction and are joined by a number of tributaries which form a more intricate system, ramifying in many parts of this lower country. The Double Mountain Fork flows into the Salt Fork in the southeastern part of the area. The Clear Fork of the Brazos just touches the extreme southeastern corner of the area. Through some of its tributaries this stream drains a small portion of the southeastern part of the area.

In the southwestern part of the area there are a few shallow, narrow valleys or draws which follow a southeasterly direction across the High Plains. These are the headwaters of some of the larger tributaries of the Colorado River. One draw, Lost Draw, extends across Terry County and part of Yoakum County, flowing into a salt lake in southeastern Terry County.

There are no perennial streams in the area, although the largest have a small supply of water in them a considerable part of the time. This water is held in pools scattered along the stream channels. Usually the larger streams have wide, flat, sandy beds, and only after considerable rains are these covered with water. Ordinarily the water flows in a narrow channel on one side of the main bed. The river sand is at times blown up out of the river bed, forming dunes of loose, drifting sand over the bottom lands or the edges of the adjacent uplands. A few creeks and small tributaries are fed by springs, but the flow is very slight, and the water soaks down rapidly into the dry beds and disappears. Most of the streams of the area have no water in them except just after rains. The draws of the High Plains rarely have water in them sufficient to flow, although some are fed by small springs.

POPULATION.

The population of the Northwest Texas area is unequally distributed. On the smooth areas suitable for cultivation and near towns and railroads the population is more dense than elsewhere. In some of the western counties there are large areas of smooth land where very few people live. On the rough lands in various parts of the area the population is scant.

The eastern part of the area was the first to be settled. The earliest settlers were ranchers. The ranching industry gradually spread westward until all of the country was taken up by a few people for grazing. Subsequent growth has come with the development of agriculture. The population increased at first gradually, and later more rapidly. From 1900 to 1910 the population of the area increased from about 22,000 to over 85,000, and since 1910 the population has continued to increase rapidly, except during the periods of dry weather that sometimes continue two or three years. According to the returns of the 1920 census the included counties have now a combined population of 116,309. Large bodies of land have been bought up by companies who have divided them into farms and have induced many people to settle on them.

The inhabitants of the Northwest Texas area are nearly all native-born Americans. Many of them are Texans from the older-settled parts of the State, but there are many from other parts of the United States. There are very few negroes, and these live mainly in the eastern part of the area. In many sections there has been a general increase of farming and a decrease in ranching.

As land values have increased in the older parts of the country and available land for cultivation has become scarce in many parts of the United States, there has been a general increase of population in this area, due to people moving in to farm the new and cheaper lands that hitherto have been used in large tracts for ranching purposes. These lands are sold at a low figure as compared with the farm lands of the central-western States from which many of the new settlers have come. Many having sold their farms in the older States or older sections of Texas, are well prepared to take up farming after moving into this country.

The table below shows the population by counties in 1890, 1900, 1910, and 1920 according to the United States census. From this may be seen the counties in which the increase has taken place.

Population of the Northwest Texas area.

Counties.	1920	1910	1900	1890	Counties.	1920	1910	1900	1890
Bailey.....	517	312	4	.....	Kent.....	3,335	2,655	899	324
Cochran.....	67	65	25	.....	King.....	655	810	490	173
Cottle.....	6,901	4,396	1,002	240	Knox.....	9,240	9,625	2,322	1,134
Crosby.....	6,084	1,765	788	346	Lamb.....	1,175	540	31	4
Dickens.....	5,876	3,092	1,151	295	Lubbock.....	11,096	3,624	293	33
Floyd.....	9,758	4,638	2,020	529	Lynn.....	4,751	1,713	17	24
Foard.....	4,747	5,726	1,568	.....	Motley.....	4,107	2,396	1,257	139
Garza.....	4,253	1,995	185	14	Stonewall.....	4,086	5,320	2,183	1,024
Hale.....	10,104	7,566	1,680	721	Terry.....	2,236	1,474	48	21
Hardeman.....	12,487	11,213	3,634	3,904	Yoakum.....	504	602	26	4
Haskell.....	14,193	16,249	2,637	1,665					
Hockley.....	137	137	44	.....	Total.....	116,309	85,913	22,304	.....

The towns in the area have populations ranging from a few hundred to several thousand. The largest and most important of these are Plainview and Lubbock on the High Plains and Quanah in the northeastern part of the area, with populations in 1920 of 3,989, 4,051, and 3,691, respectively. Other important towns of the area having several hundred to a thousand or more inhabitants are Brownfield, Littlefield, Tahoka, Slaton, Hale Center, Floydada, Lockney, Crosbyton, Ralls, Matador, Spur, Paducah, Aspermont, Haskell, Post, Benjamin, Munday, Chillicothe, and Crowell. There are throughout the area a large number of smaller towns, some of which are not on railroads.

TRANSPORTATION AND MARKETS.

The development of the Northwest Texas area has been greatly stimulated by the extension of railroad transportation facilities. The western part of the area is served by the Panhandle & Santa Fe Railway, which crosses the area diagonally and has several important branches serving all of that part of the High Plains included in this area. The main line of the Fort Worth & Denver City crosses the extreme northeastern part of the area in Hardeman County. The Kansas City, Mexico & Orient crosses the eastern part of the area, while the southeastern part is traversed by the Wichita Valley Railroad. A branch of the St. Louis-San Francisco Railway extends northward from Quanah into Oklahoma. The Quanah, Acme & Pacific extends from Quanah in a southwesterly direction through Paducah to Roaring Springs and Matador. A branch of the Wichita Valley line reaches into the southeastern part of the area, extending in a northwesterly direction to Spur. The railroads of the area afford transportation facilities to all parts of the United States. No railroad extends east and west across the area. Three counties of the area have no railroads, and several have only a few miles of railroad.

The live stock of the region is shipped to Fort Worth and Kansas City for slaughter, though much of the younger stock goes to the Western and Northwestern States as feeders. A large proportion of the other products of the area is used within the area, much of the grain sorghum produced being fed to live stock. Part of the grain sorghum and most of the wheat is shipped to the various markets in Texas and other States. Cotton is all shipped to outside markets, except what is used by the cotton mills at Post.

CLIMATE.

The climate of the Northwest Texas area is mild during the greater part of the year, though there is considerable variation in both temperature and precipitation. The climate is exceedingly healthful

throughout all the year. The following tables give the normal monthly, seasonal, and annual temperature and precipitation at Plainview on the High Plains, where the elevation is 3,370 feet, and at Haskell on the eroded or low plains, with an altitude of 1,553 feet. While weather observations have been recorded at a number of places throughout the area, it is believed that the data for these places fairly well represent the whole area.

Normal monthly, seasonal, and annual temperature and precipitation at Plainview, Hale County.

(Elevation, 3,370 feet.)

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1910).	Total amount for the wettest year (1900).	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December.....	41.9	79	-4	0.61	0.18	0.00	1.7
January.....	42.2	84	2	.40	.30	.10	2.2
February.....	41.6	91	-8	.73	T.	.52	2.1
Winter.....	41.9	91	-8	1.74	.48	.62	6.0
March.....	51.6	92	12	.45	.23	.80	.8
April.....	59.9	96	26	1.88	1.09	5.01	.1
May.....	68.3	100	24	2.30	1.93	3.40	0
Spring.....	59.9	100	12	4.63	3.25	9.21	.9
June.....	74.6	108	47	2.94	.61	3.19	0
July.....	76.8	103	45	3.98	3.16	4.74	0
August.....	76.8	103	50	2.39	2.67	3.14	0
Summer.....	76.1	108	45	9.31	6.44	11.07	0
September.....	71.0	102	33	2.39	.06	9.45	0
October.....	60.7	93	21	1.54	.77	3.21	T.
November.....	51.3	88	8	1.31	.35	1.16	1.1
Fall.....	61.0	102	8	5.24	1.18	13.82	1.1
Year.....	59.7	108	-8	20.92	11.35	34.72	8.0

*Normal monthly, seasonal, and annual temperature and precipitation at Haskell,
Haskell County.*

(Elevation, 1,553 feet.)

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1910).	Total amount for the wettest year (1900).	Snow average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December.....	44.7	83	-4	1.16	0.30	0.50	1.2
January.....	43.8	89	0	.56	T.	.32	.6
February.....	44.5	94	-5	1.01	T.	.79	2.4
Winter.....	44.3	94	-5	2.73	.30	1.61	4.2
March.....	55.1	99	12	1.20	.77	.60	T.
April.....	64.9	106	24	2.40	1.23	3.04	T.
May.....	72.8	108	34	2.98	3.00	5.93	0
Spring.....	64.3	108	12	6.58	5.00	9.57	T.
June.....	81.3	113	47	2.73	.60	5.16	0
July.....	84.7	112	54	2.66	2.11	3.35	0
August.....	84.5	115	49	1.58	.88	4.65	0
Summer.....	83.5	115	47	6.97	3.59	13.16	0
September.....	77.4	107	36	2.12	.15	2.59	0
October.....	65.4	99	30	1.97	1.08	5.78	0
November.....	53.4	91	9	1.46	.75	3.82	T.
Fall.....	65.4	107	9	5.55	1.98	12.19	T.
Year.....	64.4	115	-5	21.83	10.87	36.53	4.2

From the point of view of agriculture the question of precipitation is the most important one, as this area lies within the semiarid region of the United States. There are some years when the rainfall is not sufficient to produce the maximum of crops, and in some years not only are the crop yields rather light, but some crops do not yield at all. The periods of drought may be extended over two or three years, and even the grazing may become very scant. The chief problem of the region seems to lie in planting crops that are resistant to drought and in handling the soils so as to conserve as much soil water as possible. This problem has been solved to a considerable extent. As a rule the rainfall in the eastern part of the area is somewhat greater than in the western. The average rainfall over all the area is a little more than 21 inches. The rainfall is usually greatest in the months when crops are growing, being fairly well distributed through the season when rain is most needed. The lightest precipitation is in the winter months. The snowfall averages 8 inches per year on the High Plains and a little over 4 inches in the

lower eroded plains. As a rule snow soon melts after falling. Considerable variation is shown in the annual precipitation. At Plainview, the driest year, 1910, had a precipitation of only 11.35 inches, and the wettest year, 1900, had 34.72 inches. At Haskell, in the driest year, 1910, the precipitation was only 10.87 inches, and in the wettest year, 1906, it was 36.53 inches.

Frequently in the summer months the rains are very local, and in some very dry seasons certain sections will receive enough rain to make fair yields, while others adjacent will get very little or none whatever.

Hailstorms occur sometimes in the spring and summer months and do considerable damage, but ordinarily they are confined to small areas. The rate of evaporation of soil water is very high in this region. This is the result of the comparatively high altitude, particularly of the High Plains, the free, and in some parts of the year high, wind movement, the high percentage of sunshine, and the low relative humidity. Observations made at various stations in the area or at points just outside the area on exposed free water surfaces show an average evaporation, in the six summer months, of 48 to 60 inches. At Spur the average annual evaporation is probably 75 inches.

The winters are rather cold, though the cold usually occurs in comparatively brief periods, as the result of "northers," cold winds of high velocity from the north or northwest. These may last for several days and gradually die out as warmer temperatures return. Some of these cold spells come suddenly and are severe, being in the nature of blizzards, but, as a rule, much of the weather in the winter is mild and pleasant. The mean temperature for the winter is 44.3° F. at Haskell and 41.9° F. at Plainview. The summers are quite warm, but the heat is rarely oppressive, as the winds temper the heat remarkably. The summer nights are cool and very pleasant. Hot winds of a character to damage crops directly seldom occur. The mean temperature for the summer is 83.5° F. at Haskell and 76.1° F. at Plainview. The average annual temperature at Haskell is 64.4° F. and at Plainview 59.7° F.

The average date of the last killing frost in the spring at Plainview is April 3 and of the first in the fall October 8. This gives an average growing season on the High Plains of 188 days at Plainview, but it is doubtless several days longer in the southern part of the area on the High Plains.

The average date of the last killing frost in the spring at Haskell is March 31 and of the first in the fall November 11, giving about 225 days of growing season in that part of the lower plains region that lies in the area.

Fruit is subject to injury from late spring freezes, and the crop is frequently destroyed.

The wind movement on the High Plains is very high in certain months, especially in March and April. Although in the lower plains the wind also blows strongly in these months, it is not quite so high as on the High Plains. During the summer and fall months the winds blow much of the time, but are gentle. The prevailing wind is southerly during the greater part of the year, but in winter it is from the north and northwest. The young crops on the sandy soils are often injured by the heavy winds, which drift the sand around and over the young plants or blow the soil from about them. However, it is possible to mature crops replanted after the period of spring winds is past.

AGRICULTURE.

EARLY HISTORY AND PRESENT CONDITIONS.

As the ranching industry of Texas spread westward after the Civil War, the search for new ranges extended the industry into the eastern part of this area in the early seventies, and as that region became occupied by large ranches the High Plains region was also included by the early eighties. These ranches comprised many thousands of acres each, and the only settlements were composed of the few persons living at ranch headquarters, which were, of course, many miles apart. Cattle thrived on the nutritious native grasses of the plains and endured the winter weather with the protection afforded by the rougher areas. The cattle were driven to market until the Forth Worth & Denver City Railway was built into the region, about 1887.

No crops were grown by the early ranchers, and the native grasses were depended on entirely for stock feed. Naturally in very dry seasons, when the pasturage was short, and in very cold winters great loss was suffered through the death of cattle unable to withstand the cold when thin and in a very poor condition. It was then found very desirable to have some feed to tide the weaker or poorer cattle over the winter. Some began to grow saccharine sorghum for this purpose, and later some of the grain sorghums. One of the first settlements on the High Plains by farmers was a colony of Quakers, who settled in the early eighties near where the city of Crosbyton now stands and grew saccharine sorghum for the ranchmen. In the late eighties people began moving into the region for the purpose of farming. The number increased quite rapidly in the late nineties, and from 1900 to the present time settlement has increased rapidly, especially near the railroads, most of which have been built through the area since that year. With the advent of railroads large areas of

ranch land were cut up into farms. With the diversion of these lands from ranching to farming many ranches containing a few thousand acres each have been formed, a part of the land being used for grazing and a part devoted to the production of feed crops. Much of the land belonging to the State was homesteaded by these small ranchers, and large areas were bought from the railroads. Practically all of the public land has now been homesteaded or sold, and much of that owned by the railroads has been disposed of to ranchers and farmers. In the last 15 years a marked increase in land values has taken place. Much land held for \$2 or \$3 an acre 20 years ago now sells for \$30 to \$75 an acre. Some very good land can now be obtained for \$25 to \$35 an acre on the High Plains, but it is located a considerable distance from railroads or is unimproved if within several miles of railroads. On the rolling prairies of the Permian Red Beds region good unimproved land may be bought near railroads in some localities for \$25 to \$30 an acre, but where improved prices are much higher. Areas of rough land and of the poorer agricultural soils sell for \$5 to \$10 an acre and are utilized for pasture. A very large proportion of the farmers own the land they cultivate.

In the early years of settlement the principal crops grown were saccharine sorghum, grain sorghum, corn, and in the eastern counties wheat. Nearly all the early farmers raised some cattle in connection with their farming operations. Occasionally dry seasons of two or three years temporarily checked development, and some people moved from the region, but others continued through all the years, raising cattle and feed. Those farmers who practiced stock farming were most successful.

Farming without irrigation in this region where rainfall is irregular is more or less uncertain. However, in growing the sorghums for feed a fairly certain crop is assured in nearly all seasons, as these crops are very resistant to drought. At present the agricultural interests consist of some ranching, considerable stock farming, and the production of the general farm crops, although even with general farming many farmers also raise stock. It seems that, with a number of forage crops well suited to the climatic conditions, stock farming is the most dependable type of agriculture for this region.

The tables given below, which are compiled from the reports of the Bureau of the Census, contain summaries of certain selected statistics relating to the counties included in the area surveyed. However, in considering these tables it must be remembered that these figures are totals and averages for an area comprising 22 counties and over twelve million acres of land, and that consequently they indicate conditions and tendencies in agriculture only in a very general way.

Farms.

	1920	1910
Number of farms.....	<i>Number.</i> 13,475	<i>Number.</i> 10,293
Average size of farms.....	<i>Acres.</i> 701	<i>Acres.</i> 1,032
Land in farms.....	9,458,350	10,617,500
Improved land in farms.....	2,000,062	1,315,865
Per cent of land in farms.....	<i>Per cent.</i> 74.9	<i>Per cent.</i> 84.1
Per cent of farm land improved.....	21.2	12.4
Per cent of farms operated by tenants.....	48.2	48.3

Cattle, sheep, and hogs on farms.¹

	1920 ^c	1910
Cattle.....	448,322	534,521
Beefcattle ²	398,099	
Dairy cattle ²	50,203	
Sheep.....	86,462	14,627
Hogs.....	113,684	55,911

¹ In 1920 the enumeration of live stock was made as of Jan. 1, and in 1910 it was made as of Apr. 15.

² This classification was not used in the census of 1910.

Acreage and production of leading crops.

	1919		1909	
	<i>Acres.</i>	<i>Bushels.</i>	<i>Acres.</i>	<i>Bushels.</i>
Corn.....	75,250	2,546,634	118,833	1,142,366
Oats.....	48,338	1,941,900	17,105	145,948
Wheat.....	347,035	5,826,224	32,440	296,475
Kafir, milo, etc.....	512,018	12,772,193	111,975	1,297,651
Cotton.....	497,236	<i>Bales.</i> 239,145	238,727	<i>Bales.</i> 50,805
Hay and forage.....	253,356	<i>Tons.</i> 378,247	89,613	<i>Tons.</i> 82,167
Tame grasses.....	17,144	20,715	20,119	19,201
Kafir, sorghum, etc., for forage ¹	220,247	327,441	67,996	61,908

¹The figures for 1909 are the figures for "coarse forage," which includes some corn cut for forage.

The gradual change from ranching to general farming combined with stock raising is clearly indicated in these tables. The increase in the number of farms from 1910 to 1920 is due to the breaking up of ranches and large holdings into farms, rather than to an extension of farming into unoccupied lands. This is evidenced by a decrease of nearly one-third in the average size of farms, and a slight decrease in the total area included in farms, accompanied by an increase of nearly 50 per cent in the acreage of improved land. This trend toward farming is also shown by the decreased number of cattle and the increased number of other live stock on farms, and par-

ticularly by the marked increase in acreage devoted to field crops, especially wheat, cotton, grain sorghums, and forage.

The average size of farms ranges from 240.8 acres in Haskell County to 30,324 acres in Cochran County. The average size in Cottle, Crosby, Dickens, Floyd, Foard, Hale, Hardeman, Haskell, Knox, Lubbock, Lynn, and Stonewall Counties is less than the average for the area. There is a tendency toward an increase in the size of farms in a few counties, mainly those with the smaller farms. The proportion of improved land in farms ranges from less than 1 per cent in Cochran and Hockley Counties, which are sparsely populated, to 49.5 per cent in Floyd County and 53.8 per cent in Haskell County.

The distribution of cattle is remarkably uniform. No county had less than 9,000 cattle on farms in 1920, one county had over 46,000, and 17 counties had between 15,000 and 30,000 cattle per county. Sheep and hogs are unevenly distributed. More than two-thirds of all the sheep in the area in 1920 were credited to Hale, Lubbock, and Stonewall Counties. Some hogs are raised in every county, but Hale and Floyd Counties have the greatest number.

The corn crop in this area is so variable and uncertain that the statistics of any particular year are not very significant. The fact that corn occupied 43,583 acres less in 1919 than in 1909 would suggest that the acreage was less throughout the area, but such is not the case. In 10 counties the acreage was less in 1919 than in 1909, and in 12 counties it was greater. In the 4 counties in the eastern tier corn occupied 76,195 acres in 1909 and only 20,869 acres in 1919, or 55,326 acres less. Accordingly, in the remaining 18 counties the aggregate acreage of corn was actually greater in 1919 than in 1909.

Oats were grown in 10 counties in 1909 and in 18 counties in 1919.

Wheat was grown in 10 counties in 1909 and in 19 counties in 1919. However, wheat growing is not uniformly developed in the area, more than 80 per cent of the wheat acreage in 1919 being confined to Hale and Floyd Counties in the north, and Hardeman, Foard, Knox, and Haskell Counties in the eastern part.

The grain sorghums, including kafir, milo, and some other varieties, were grown in every county in the area in 1909 and in 1919. However, these crops are grown most extensively in Hale, Floyd, Crosby, Lubbock, and Lynn Counties, considerably more than half of the grain sorghum acreage in 1919 being found in these counties.

Cotton is grown mainly in the central and eastern parts of the area. In 1919 it occupied more than 17,000 acres in each of 14 counties, excluding Hale and King Counties and the 6 counties farthest west. Haskell county led with 85,576 acres, followed by Knox County with 53,645 acres. In 1909 the cotton acreage was limited largely to the eastern part of the area, Cottle, Foard, Hardeman,

Haskell, Knox, and Stonewall Counties having acreages ranging from 17,000 to 75,000 acres each.

Hay and forage crops are grown more or less in every county. Hale County led in 1919 with 37,640 acres. In every part of the area the greater part of the crop consists of coarse forage from kafir and sorgo.

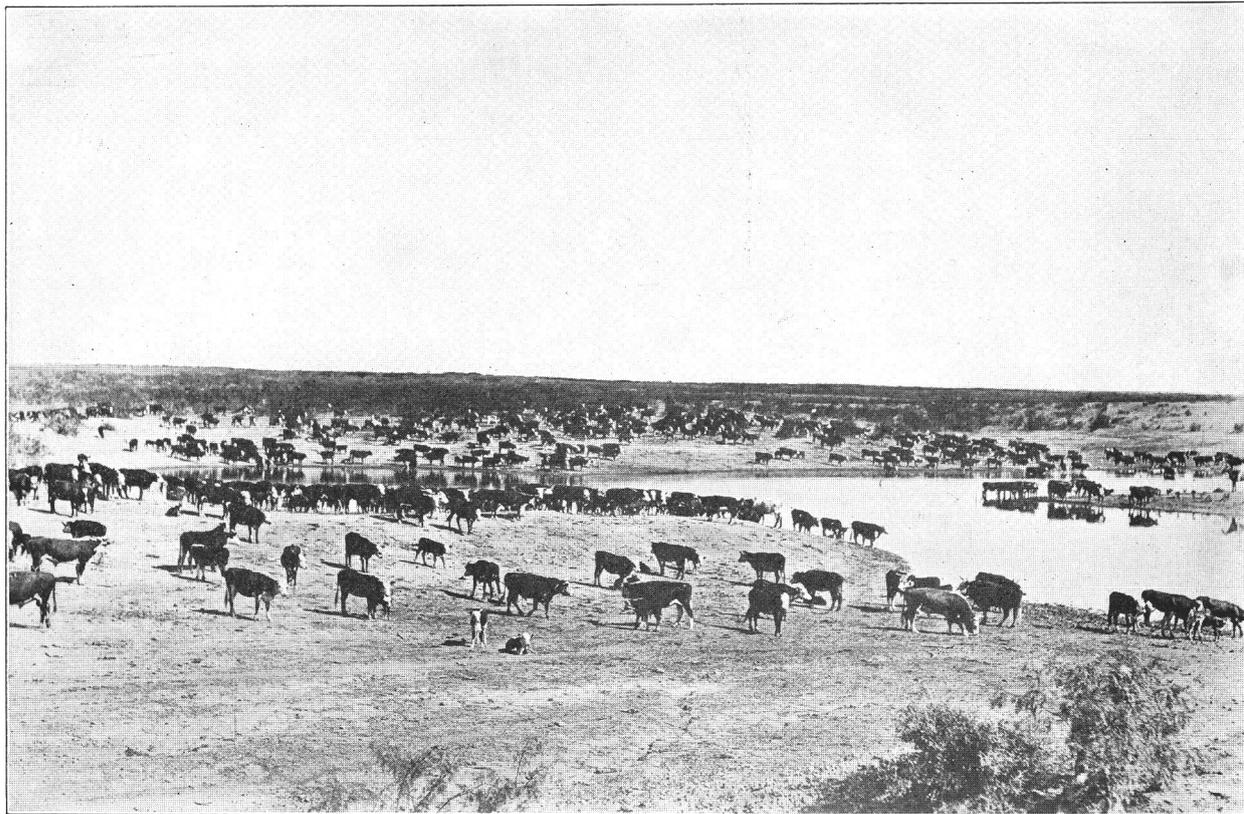
STOCK RAISING.

There are now only a few ranches in this region that contain more than 100,000 acres, but stock raising is still the important industry and will doubtless continue to be, though under a more intensive system than heretofore. Most of the large ranches are in the western counties of the High Plains and in the rougher areas of the rolling plains in the eastern part of the area. There are still many small ranches, containing from a few hundred to several thousand acres, in all parts of the area. On many of the farms of the area as many cattle as possible are raised. Thus stock raising is carried on in a number of ways, ranging from the system on the very large ranch, where practices are somewhat the same as in the early days of the industry, to the more intensive methods of the small stock farmer; and notwithstanding the settlement of the country it is probable that there are nearly as many cattle in the area now as when ranching was the sole industry. Cattle raising is by far the most important live-stock industry in the area, though many sheep, hogs, horses, and mules also are raised.

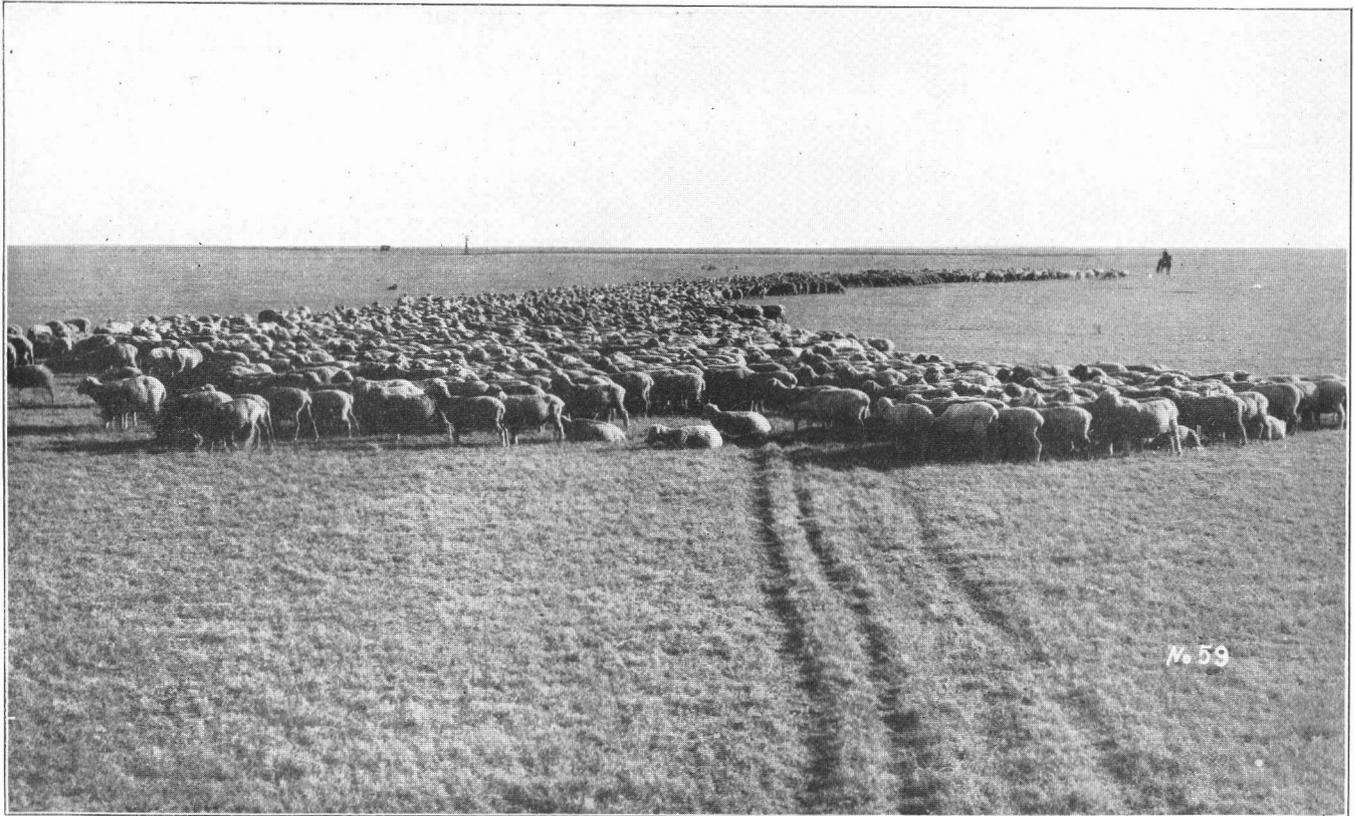
The native Texas longhorn cattle originally raised have given way entirely to the improved breeds, and nearly all the cattle now are grade Herefords of good quality. This has been brought about by using purebred stock for crossing with the native stock. Also, many herds are purebred. Plate I shows a drove of Hereford cattle grazing on Vernon soils.

In the early years of ranching the cattle were run on the range the entire year without additional feed. The prairie grasses are very nutritious, and on maturing "cure on the ground," affording good winter grazing.

In very dry seasons, when grass did not make a heavy growth, the stock became quite thin in the winter and in very cold spells died. It is now the practice of all the stock raisers to feed some of the thinner stock and the breeding cows during a part of the winter. This carries the weak stock through and insures a good calf crop in the spring. In some severe winters all the stock is fed sometimes for several weeks. Kafir, milo, and sorghum are the principal feeds, and many supplement these with cottonseed-meal cake. Some of the large ranchers use only the latter feed. Most of the cattle raised in the area are sold and shipped to other States to be fattened for

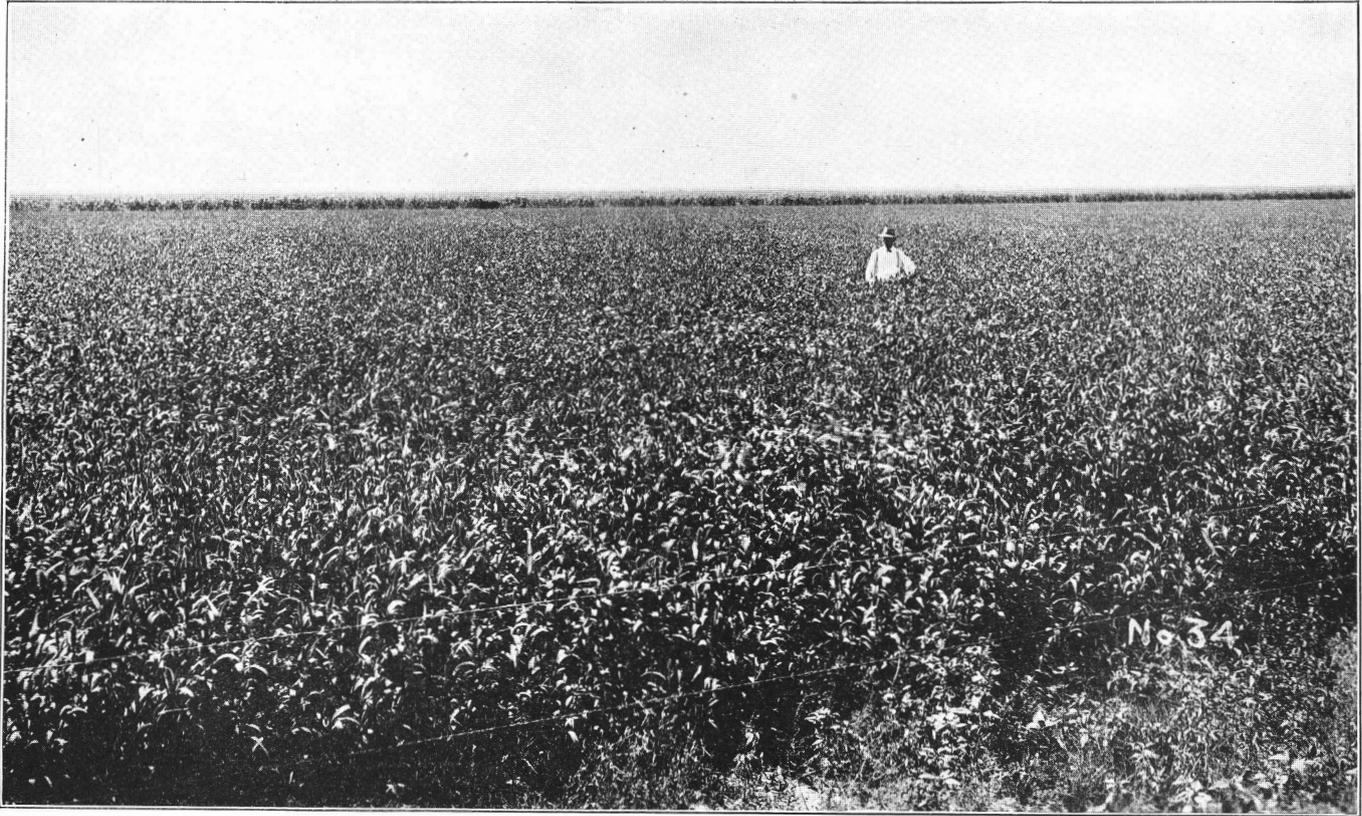


HEREFORD CATTLE GRAZING ON VERNON SOILS (RED LANDS).



SHEEP ON THE AMARILLO CLAY LOAM, WEST OF PLAINVIEW.

Sheep raising is an important industry in the western part of the High Plains. Note the topography and even stand of grass.



FIELD OF MILLET ON THE HIGH PLAINS.

This field was irrigated.



SUDAN GRASS ON THE HIGH PLAINS.

This introduced grass has proved well adapted to the soils and climatic conditions of the region. It is a valuable forage crop.

the market. Some, however, are shipped for slaughter to packing houses at Fort Worth, Kansas City, and Oklahoma City.

Dairying is carried on near the larger towns to supply the local market. The region is well adapted to this industry, and doubtless dairying could be profitably extended, especially near the towns.

Some large and small flocks of sheep are kept in various parts of the area, and sheep raising is quite profitable. The largest sheep ranches are in the western part of the area on the High Plains in Hale, Lamb, and Bailey Counties. (Pl. II.)

It is probable that sheep raising on a small scale could be established to advantage on a great many of the farms in the area.

A very considerable number of hogs are raised throughout the area, but the industry seems somewhat more popular on the High Plains than in other sections. The number of hogs raised is increasing rapidly from year to year. The production of hogs has proved very profitable in the region, as all the feedstuffs grown are suitable for hog feed, and the region seems to be quite free from diseases peculiar to this animal. Winter grazing is obtained from small grains, while the sorghums furnish the grain feed. Small areas of alfalfa also are used for hog pasture.

A great deal of the work stock used on the farms and ranches throughout the area is raised in the area. However, mules and horses are not raised on a large scale.

PRINCIPAL AGRICULTURAL PRODUCTS.

There is a considerable range of agricultural products in the Northwest Texas area. The grain sorghums, mainly milo, kafir, and feterita, are important crops in all parts of the area, milo being grown more largely than the others. Sorgo (saccharine sorghum) is also grown on almost every farm. Cotton is grown throughout the lower plains and on the High Plains as far north as the southern parts of Floyd, Hale, and Lamb Counties. North of this general latitude on the High Plains the higher altitude, cooler nights, and shorter growing season make the growing of cotton somewhat less certain than in the more southerly areas.

Considerable wheat is produced on the heavy soils of the High Plains and also in the lower plains region. Most of the wheat acreage on the High Plains is in Hale, Floyd, and Crosby Counties and in the low-plains region in Hardeman, Foard, Knox, and Haskell Counties. Besides these main crops there are corn, oats, alfalfa, Sudan grass, millet, emmer (locally called spelt), broom corn, and other less-important products.

GENERAL FARM CROPS.

Probably the grain sorghums are the most important crops. The grain of these crops is a very nutritious feed. These sorghums are

well suited to regions of moderate rainfall, and even in the drier seasons they yield some grain. They grow well on all the soils of the area. Milo is grown more extensively than kafir and yields more grain under the same conditions. It is grown principally for the grain, as the fodder is not very palatable to stock, being rather tough and woody. The grain is relished by stock of all kinds and has about the same feeding value as corn. In favorable seasons milo yields 25 to 50 bushels per acre; in dry years the yield falls below 20 bushels. The crop is seldom a failure. The Dwarf Yellow is the principal variety of milo grown.

Kafir is very similar in appearance to milo. As a rule, the yields of grain are somewhat less, but the fodder is of more value than that of milo. Three to four tons of fodder per acre are obtained. The Dwarf Black Hull is the leading variety of kafir.

Feterita (*Spur feterita*)¹ is a very valuable grain sorghum, which as yet is grown only in a small way. It was originated at the Texas Agricultural Experiment Substation near Spur and is becoming popular. It is somewhat more resistant to adverse weather conditions than milo or kafir. The grain sorghums in the region are fed largely to stock, taking the place of corn. Large quantities are shipped out of the area and sold for feed.

Sorgo, long grown in the region, is a very reliable forage crop. It is resistant to dry conditions and yields some forage in very dry years, while with fair moisture conditions it returns 3 to 6 tons of forage per acre. Two crops may be obtained in one season. When plowed under it makes an excellent green manure.

Wheat has been grown for many years in the extreme eastern part of the area and for a number of years on the heavier soils on the High Plains. While the heavier soils are well suited to the production of wheat, the yields are more or less uncertain on account of dry seasons. In some years rainfall is so light that wheat fails to mature grain. This uncertainty has resulted in cotton taking the place of wheat to a considerable extent in the eastern part of the area. However, on the High Plains wheat is grown on a considerable acreage, and if the crop is badly damaged by dry weather the land is utilized for grain sorghums or sorgo. This system is followed in all parts of the area.

In good seasons wheat yields from 15 to 35 bushels per acre. The Turkey is the principal variety. Some spring wheat is grown with fairly good results, but the spring-sown crop is very susceptible to damage by rust.

Wheat is sown preferably about the middle of September in the High Plains and about four weeks later in the low plains. When wheat follows wheat, the seed bed should be prepared early and there-

¹ Bul. No. 275, Texas Agr. Expt. Sta.

after given sufficient tillage to prevent weed growth, and to conserve soil moisture by preventing excessive evaporation. Probably the best method of preparing the land for wheat is to plow or double-list the land as early as possible after the previous crop has been removed, and then disk and harrow or use the "go-devil" cultivator and harrow until the soil is in a friable condition. Usually it is beneficial to harrow the land after rain to prevent loss of moisture by evaporation and to prevent weed growth. Many farmers, however, do not have the time to give the land thorough preparation, but drill the wheat on stubble land without preparing a seed bed.

Wheat is used to a great extent for winter grazing and is excellent for this purpose.

Oats are grown in the same general sections as wheat. The crop, however, frequently does not yield well or fails altogether on account of dry winter and early spring conditions. In good seasons oats yield from 25 to 50 bushels and some years have made as much as 80 or 90 bushels per acre. Oats are sown in the spring, usually in February.

Barley and rye are grown very little in the area, being used chiefly to furnish grazing in the winter and spring. These grains, however, yield well when the season is favorable.

Cotton is a very important crop in the area, though it is not grown extensively in the northern counties of the High Plains, wheat here taking its place. The principal cotton-growing counties of the High Plains are Lubbock, Crosby, Lynn, and western Garza, eastern Terry, and the southern parts of Hale and Floyd.

Cotton is the important cash crop of the counties of the lower plains. Cotton seems to be well suited to the region, except in the higher parts of the High Plains, and even here it makes fair yields in favorable seasons.

With ample rainfall the heavier soils produce the best yields, but the sandy soils with heavy subsoils give better yields in dry seasons. Yields range from one-fourth to one-half bale per acre in fair seasons, but range as high as one bale under especially good conditions. In very dry seasons the crop may be a complete failure, but this is very rare. The boll weevil is not a menace in this region. The principal variety grown in the older cotton-growing or eastern part of the area is the Mebane, with a small quantity of Lone Star and Acala.

Land for cotton is prepared by listing, the seed being planted in the furrow. It is planted about the middle of May in the lower plains and somewhat later on the High Plains.

Millet is grown throughout all sections of the area, though only in a small way by some farmers and not at all by many. This crop does well on all the soils and gives heavy yields of valuable forage and seed

under favorable conditions. Plate III shows an irrigated field on the Amarillo clay loam.

Alfalfa is grown by many farmers on the heavier soils of the area. On the High Plains there are some good-sized areas devoted to it, and in the northeastern part, in Hardeman County, some large fields have been planted to this crop. Many farmers throughout the area have small patches of alfalfa. Some of the fields in the High Plains are irrigated from wells, and in Hardeman County from impounded surface water. Under irrigation the crop yields 3 to 5 tons or more per acre per season. In good seasons nearly this much is made without irrigation, but in dry seasons the yield is much less. The crop is especially good for grazing, and hogs are run on it with excellent results. In fact, in many places it is grown especially for hogs, a practice that has proved very profitable. On the High Plains alfalfa grows best on the narrow alluvial bottom lands, on the Amarillo clay loam, and on the Richfield silty clay loam. In the Permian Red Beds region the crop does best on the bottom lands. Three or four cuttings a year are obtained.

Throughout the region some corn is planted, but the crop is uncertain, owing to the frequent lack of rain at critical times in the spring and summer. In fact, there seems to be no good reason why corn should be grown, as the grain sorghums have practically the same feeding value and are more drought-resistant, rarely failing to mature some grain, even in the driest seasons, and over a period of years the grain sorghums will produce from 30 to 50 per cent more grain than will corn. Probably the soils best suited to corn in the region, taking into consideration the more favorable location at lower altitudes, are the Miles and Vernon sandy soils and Derby loamy fine sand. In good seasons corn yields 20 to 35 bushels per acre and sometimes more.

Small plantings of broom corn are made with success in various parts of the area. Yields are fairly certain, and this crop could be grown more extensively to good advantage.

Peanuts do well on the sandy loams, and some are grown for market.

Sugar beets have been grown successfully in the High Plains under irrigation, but they were grown more as an experiment than for market.

Sudan grass is a valuable forage crop introduced into the United States in 1909 by the Texas Agricultural Experiment Station cooperating with the U. S. Department of Agriculture at the State Substation No. 12, Chillicothe. This crop has become especially popular in the High Plains, owing to the work at Substation No. 8, Lubbock. It is an important feed crop, yielding two or three cuttings a year of more than 1 ton per acre at each cutting. It is valuable for hay and for grazing. It is also grown for seed, yielding 400 to 500

pounds per acre. Many farmers in Lubbock and adjoining counties grow this forage crop, and many others are beginning to grow it in various parts of the area. Plate IV shows a field of Sudan grass in the High Plains.

TRUCK CROPS.

Truck crops are not grown on a commercial scale in the area except in a small way around the larger towns to supply the local markets, but vegetables are grown on every farm for home use. In seasons of ample rainfall vegetables thrive. When the rainfall is insufficient the home gardens are irrigated with water pumped from wells by windmills. Thus it is always possible to have vegetables on every farm. Though vegetables do best on the sandy soils, they also grow well on the heavy soils.

Vegetables are rather late in this region; therefore it is doubtful if truck farming on a large scale for outside markets would pay. It is probable, however, that more vegetables could be produced for the local markets with profit. Watermelons do well on the sandy soils throughout the area. Muskmelons yield well and are of very fine quality. Irish potatoes, while not producing so well as other vegetables, could doubtless be grown more extensively for home use. The sandy loams are suited to this crop. Sweet potatoes do well, especially on the sandy loams. Beans, peas, tomatoes, cabbage, eggplants, beets, turnips, peppers, rhubarb, cucumbers, lettuce, and other vegetables grow well on all the soils, but do best on the soils of sandy and loamy texture.

FRUITS.

While no commercial orchards are found in the area, there is considerable fruit grown in a small way, nearly every farm having a small orchard. Most of the trees are apples, peaches, and plums, though other fruits, among them cherries, pears, grapes, and apricots, also are grown. All fruits do well in so far as soil conditions are concerned. The chief drawbacks to their production are dry seasons and late frosts, but the high winds also do more or less damage. The home orchards can be irrigated by means of windmills, and this is frequently done.

AGRICULTURAL METHODS.

Agricultural methods as practiced in the Northwest Texas area vary according to the soils and crops grown throughout the region. Some practices prevail that may not be found in other parts of the State or in other States. These are the results of farm experience in a country where the early farmer had little to guide him, but had to try out various methods until the best ones for his conditions were found. Frequently, however, by reason of farming too much land or because of scarcity of labor, the farmer is not able to practice some of the methods he knows are best.

Since the rainfall in this region is irregular and sometimes insufficient, it is most important to practice those methods of tillage which conserve soil water for the use of growing crops. This should be done by preparing the land so that the largest possible quantity of rain water will be absorbed by the soil and by employing methods to keep the water in the soil. These methods vary according to the character of the soil, although the general principles may apply to all the soils. From a textural standpoint there are five general classes of soil in the area. These are roughly grouped by farmers into two classes as "tight land" and "sandy land," but may be further subdivided into (1) the loose sands, (2) sandy loams or fine sandy loams with clay subsoils, (3) moderately friable soils such as the loams, (4) fairly heavy soils, as the clay loams, and (5) the very heavy soils or clays. The sandy soils, being porous, absorb water readily, and where there is a clay subsoil the type retains water very well, since evaporation is not rapid, the loose sandy surface layer acting as a mulch. The loams and clay loams take up water more readily than the clay soils, provided the surface conditions are essentially the same. Much of the surface water runs off the less absorptive, unbroken heavy soils and is lost. Therefore, if the land has been plowed and left rough it will absorb more water, and for this reason it seems best to plow the land in the fall to collect the winter and spring rains. The land should be stirred to a shallow depth with sufficient frequency to maintain a surface mulch. A mulch consisting of 3 or 4 inches of stirred soil will quite largely prevent the loss of soil water by evaporation, and the renewal of this mulch when the land crusts over will also kill grass and weeds which otherwise would deplete soil moisture. The farmers of the region realize the importance of these methods and practice them to a great extent when possible.

On the sandy soils the crops are frequently damaged in the spring by heavy winds which drift the sand over the plants or blow the soil from around them. It has been found that leaving the surface as rough as possible and having as much vegetable matter in the soil as possible tend to prevent damage by winds. Also it is considered advantageous to run the rows east and west at right angles to the prevailing wind directions, throwing up high ridges in listing, thus protecting the young plants growing in the furrows between the ridges. While the heavier soils do not blow so badly, they may, if pulverized very fine, form a dust that does drift to some extent, so that it seems advisable instead of working up a fine, loose soil structure, rather to have a moderately fine mulch or fine clod mulch.

Some farmers practice summer fallowing, breaking the land and giving it shallow cultivation after rains throughout the spring and summer, and sowing wheat in the fall. In this way moisture is con-

served, and at the same time the land rests for a certain period. The practice is said to give very satisfactory results.

No well-defined system of crop rotation is practiced in the region, but a change is made from cotton to feed crops, or to wheat, as the case may be, from time to time. It is claimed that this is very satisfactory. Nevertheless, many grow the same crops year after year on the same land. In this region, where the lands are comparatively fresh and new, this practice has not as yet affected yields in any marked degree. A falling off in productiveness may be experienced when the practice has been continued longer.

The Texas Agricultural Experiment Station has three substations in the area, located at Lubbock, Spur, and Chillicothe. At these stations valuable work is being done in testing new varieties of crops, studying different methods of tillage, and in carrying on many other investigations. The farmers of the State should keep up with these investigations and make use of the results where they apply to their particular soil and cropping conditions.

SOILS.

GENERAL DISCUSSION.

The various geological formations of this region give rise to soils that differ with the original character of the material and the conditions under which it has weathered. A brief description of these rock formations will give a better understanding of the manner in which they have influenced the character of the soils derived from them.

Relation of soils to geological formations.

Manner of accumulation.	Age of geological formation.	Soil.
Alluvial.	Tertiary and quaternary.	Alluvial soils, undifferentiated.
	Permian, with some tertiary and quaternary material.	Miller. Bastrop.
Aeolian.	Tertiary, quaternary.	Derby.
Residual from old unconsolidated sedimentary material.	Tertiary, quaternary.	Miles. Amarillo. Richfield. Brackett.
Residual from consolidated marine sediments.	Permian.	Vernon. Foard.
From consolidated and unconsolidated sediments.	Permian. Tertiary. Quaternary. Triassic.	Rough broken land. Rough stony land.

A large part of the area east of the High Plains, comprising approximately half of the area surveyed, is underlain by Permian Red Beds.² These are the oldest rocks of the area. They constitute the main basal stratum of a large region in northwest Texas, including most of the country lying between the West Cross Timbers and the High Plains. This Permian formation occurs mainly in Hardeman, Foard, Knox, Haskell, Stonewall, King, Cottle, Motley, Dickens, Kent, and Garza Counties.

The Permian rocks consist of Indian-red and bluish clay, shale, and sandstone, with some interbedded limestone and layers of gypsum and rock salt. The material composing the rocks of this formation is of marine origin. It contains considerable gypsum, sodium chloride, and other salts which render the water more or less unpalatable. These rocks on weathering have produced soils more or less closely related, and grouped chiefly in the Vernon series. The layers of gypsum are not continuous and range from a few inches to a foot or more in thickness. Where they come to the surface, as they do in a number of small areas, stony soils are formed.

In the border counties on the eastern side of the area there are bodies of nonred soil derived from the Permian rocks. This lack of red may be due in part to the occurrence here of Permian rocks which themselves are not red, but probably these soils owe their color, which is normally dark, to somewhat deficient drainage, which has retarded oxidation and favored accumulation of dark-colored organic matter. The dark soils derived from the Permian rocks have been included with the Foard series.

The western half of the area is covered by deposits of the Late Tertiary and Pleistocene ages. These underlie the High Plains part and some of the lower rolling and broken country just east of the High Plains escarpment. These deposits were laid down by streams which probably were shallow and possibly broad and gently flowing, rising in the Rocky Mountains and flowing eastward. These streams were shifting and sluggish. It would seem that detritus brought from the west was carried many miles east of the present eastern boundary of the material and that much of this deposit has been gradually eroded and washed away, uncovering the underlying older formations.

On the High Plains the Tertiary material in the lower beds is gravelly and sandy, and the upper part is a uniform soil material over large areas. From the weathering of these fluvial or lacustrine deposits two main soil series are formed. The Amarillo series includes those soils of the High Plains that are brown to red in color,

² The geological information in this report is taken largely from Bulletin 44 of the University of Texas, entitled Review of the Geology of Texas, and from Water-Supply Irrigation Papers Nos. 154 and 191, U. S. Geological Survey.

while the darker soils occurring in close association with these have been classed with the Richfield series. Just east of the High Plains escarpment, and extending eastward over considerable areas of the eroded plains in Motley, Dickens, and Garza Counties, there are beds of fine conglomerate, quartz, sandstone, and other rocks, the embedded stones consisting of smooth, rounded gravel. This rock is probably of Pleistocene or Tertiary age, though small beds of Triassic age also occur as a narrow band under the last escarpment of the High Plains. The Triassic beds are identified by gray and brown sandstones and variegated, maroon, wine color, white, lavender, and yellow shales, and by extensive cross-bedding and local unconformities. These fluvial beds give brown to red sandy soils with red subsoils and were included with the Miles series. Adjacent to the escarpment most of the Triassic beds lie in the Rough broken land areas, and no soil types were identified as being derived from this formation, although in some places the soil material of the Miles soils may be in part derived from the Triassic. Much of the sandy material on the High Plains is reddish and gives soils of the Amarillo series. In the western part of the area on the High Plains there are some large areas of deep, loose sand that has been blown into dunes and ridges by the heavy winds. Much of this is yellowish with a gray surface and was mapped as a dune phase of the Derby fine sand. On the eroded plains there are also large areas of the loose yellow fine sand with a surface color of gray or grayish brown. All this, or a large part of it, has been blown from the beds of the large streams. The sand has been washed from the Tertiary and Pleistocene areas and deposited over the beds of the streams. As these beds are dry most of the time, the wind blows the fine sand up many feet deep onto adjacent areas of the Permian Red Bed soils. In many places the sand has been blown into dunes of considerable size. Such areas occur mainly in Stonewall, Kent, Motley, and Cottle Counties. The soil is included in the Derby series. In Hardeman County a loamy fine sand of the same derivation, but slightly reddish in color in the subsoil, is also included in the Derby series.

The boundary lines between the major soil groups of the world are not sharp. The broad groups are distributed in belts and are due to gradually changing temperature and moisture supply. Probably in no place on the earth's surface does the rainfall or temperature change with sufficient rapidity to make it possible to draw a line on a map of such a region separating the belt with what would generally be recognized as a humid climate from an adjoining belt that would be recognized as a subhumid or a semiarid climate. While this is true in general, it is especially true of the change of this kind which takes place within an area of smooth topography. On the broad, smooth plain stretching eastward from the Rocky Mountains

no feature of the relief is strong enough to effect any sudden change in the character of the climate. The change taking place from east to west occurs gradually, and at no point or along no line is there any marked difference between the conditions immediately on the east and those on the west.

The broad features by which the soil is characterized at maturity are features impressed on it by climatic conditions, so that in a region of smooth topography, where conditions favor the development and persistence of mature soils over a long period of time, there can be no sharp boundaries between the various soil belts. The soils within the central belt of any soil zone will be characterized by the perfect development of the features characterizing the soils of that belt. In both directions from the central zone these features become less perfectly developed, and at a certain distance away the features of the adjacent belt appear, faintly developed at first but increasing in strength expression to a maximum in the central zone.

In any given belt the characteristic soil features, even along the central zone, will be well developed only in the mature soil. In the alluvial soils, many shallow soils, and others not yet mature and made up of material accumulated in relatively recent times, these features may not be manifest at all or may be present in imperfect development. The young or immature soils will occur in alluvial belts, alluvial fans, on mountain and hill slopes, and areas of rapid erosion of whatever kind.

In soil differentiation preliminary to soil mapping, boundary lines between the various soil belts must be drawn. These lines must necessarily be more or less arbitrarily placed for reasons already stated, and in interpreting their significance the conditions controlling their location should be kept in mind.

Changes in rainfall and temperature express themselves in changes in the features of the soils. Where changes in both run parallel but in opposite directions—that is, where decrease in rainfall is accompanied by increase in temperature, or vice versa, the soil belts will be long and narrow, but where they run at right angles the soil zones become soil areas. Where they run parallel and in the same direction the belts will be long but may be wide or narrow, depending on the relative rate of change. It is not necessary to discuss fully the possibilities in such cases, but suffice it to say that within the areas of the Northwest Texas Reconnaissance the soils are distributed in belts which run across the area from north to south.

The area covered by the soil map lies across the boundary of two belts and includes portions of both—the western part of the eastern belt and the eastern part of the western belt. The greater part of the area lies in the western belt. The boundary line be-

tween the two belts enters the area in Hardeman County and runs slightly west of south through the eastern part of Cottle, the eastern part of Kings, and the central part of Stonewall Counties.

The mature soils in the eastern belt are characterized by a very dark brown to black surface horizon often more than a foot in thickness with a granular structure, a subsurface of brown or dark brown or brown traversed with vertical tongues of dark-brown color to a depth ranging from 24 to 36 inches, and a lower or third horizon of highly calcareous material which may vary from a brown heavy clay with spots, streaks, or concretions of carbonates to a pinkish-white or gray marl of nearly pure carbonates.

These are the features of the profile of the mature soil and are best developed on flat areas only and in soils of heavy texture. In sands no changes take place from the surface downward other than a change to a lighter color beneath the surface horizon, due to a smaller quantity of organic matter in the subsurface horizons. In the soils of intermediate texture, such as the sandy loams, the surface horizon is not so dark as in the heavier soils. The subsurface is usually reddish brown in color, and the carbonate horizon is deeper and less perfectly developed. The carbonate occurs in flecks, concretions, and streaks, less frequently in concentrated form. On slopes and in areas where drainage is rapid or the soil shallow the surface soil is much lighter in color. The erosion on slopes may wash the surface soil away too rapidly to permit the accumulation of a layer with a great deal of organic matter, or the thorough drainage may favor the growth of brush or small trees rather than grass and thus promote the formation of a light-colored soil. Along the rims of canyons or valleys the carbonate horizon is thicker, usually developed into a limestone rocklike layer often 10 feet in thickness or even more. The distance to which it extends back from the outcrop on the canyon brink is not known, but is probably not more than a few yards.

The mature soils of the western belt, including the greater part of the area covered by the soil map, are characterized by a dark-brown surface horizon extending usually to a depth of about 8 inches, and a reddish-brown to brown subsurface horizon extending from 8 inches to a depth ranging from 16 to 24 inches. It is brown in color and may effervesce in acid. This horizon is underlaid by the horizon of carbonate accumulation.

These soils differ from those of the eastern belt in the lighter color of the surface horizon and the occurrence of the carbonate horizon at a shallower depth. The surface horizon has a less well-defined granular structure than in the eastern horizon, but in many places it has a well-developed columnar structure manifested in the vertical cracking of the dark-colored horizon on outcrops along the

sides of cuts. On account of the lighter color of the surface horizon, resulting from the lower content of organic matter, the red color so universally present in the well-drained soils of southern latitudes is more manifest in these soils than in those of the eastern belt. The subsoil colors do not differ to any marked extent in this respect.

A considerable part of the area of this belt consists of small depressions in which the soil is darker in color than the typical soil, has a darker colored subsurface with very little tendency to a red color, and a carbonate horizon much like that under the soils of the eastern belt. In fact, these soils are closely related to the latter because of their higher moisture supply. The carbonate horizon becomes thick along the rims of canyons exactly as is the case in the eastern belt, and the immature soils, whatever the cause of their presence, are marked by the faint development or absence of the features marking the mature soils.

The characteristic features of the soils of any of the great soil belts of the world are to be found in the mature soil of that belt only. The characteristic profile of the soils of the eastern belt described above is that of the Foard soils, while the profile of the western belt as described above is that of the Amarillo soils. The features of the soils of each of these two series persist over large areas extending from southwestern Oklahoma southwestward, apparently across the international boundary and beyond. Soils with characteristics very much like those marking these soils are found in a northward extension of each of these belts reaching to the Canadian boundary and beyond. The eastern belt crosses the international boundary in northeastern North Dakota. The soils of the northern ends of these belts are usually darker in color than are those of the southern ends, and the subsoils are gray to light brown rather than reddish brown to red, as is true of the soils of the southern ends of the belts.

The prominent features of the soils of the eastern belt correspond closely to the features of the soils of the Tschernosem soils found in perfect development in southern Russia, while those of the western belt seem to fit the description of the soils of the chestnut-colored soil belt of southern Russia.³ The distribution of these belts in this country has been only approximately determined.

All mature soils and those approaching maturity in both the soil belts in this area are characterized by a horizon containing a high percentage of carbonates, predominately calcium carbonate, in the subsoil. This feature is common to the mature soils of these belts as well as to those in all the soil belts developed under moderate to low rainfall. Carbonates appear in the deep subsoils of northern

³ K. D. Glinka. Die Typen der Bodenbildung, pp. 102 to 140. Berlin, 1914.

Texas soils approximately on the 26-inch rainfall line, and in southern Texas on that of 28 inches rainfall. In northeastern North Dakota they appear approximately on the 20-inch rainfall line, possibly on the 19-inch line. Throughout the northern and central parts of the United States the carbonates never, or at least very rarely, occur in the soils of these two belts in the form of a hard, stony horizon or caliche. In northern Texas they occur in places as a hard, calcareous horizon, but, so far as is now known, only on the brinks of canyons or other steep slopes, and seem to extend back from the edge or outcrop a very short distance. (Pl. V, fig. 1.) In areas of smooth topography the carbonate horizon consists of spots and streaks of soft carbonate scattered through the subsoil material or of a marly material with a nearly uniform gray or pinkish-white color. Throughout the southern and southwestern parts of the United States, where the carbonate horizon has developed to a caliche or hardpan, it is found on or within a few feet of outcrops in banks or valley slopes, under gravelly or sandy cover or in places where the cover, whatever texture it may have, is but a few inches in thickness. Throughout northern Texas, at least, no case has been observed where a well-developed caliche has been found underlying a heavy soil, the nearest approach to such a horizon under heavy materials being beds of calcareous concretions embedded in clay.

In northern Texas the carbonate horizon in the Tschernosem, or, as it will be designated here, the Abilene-Foard belt, never attains the thickness and degree of induration of a caliche; whether it does so farther south is not known, but no case is known to soil literature, so far as that has been examined, where such development has taken place. This belt is the most easterly of the belts in which the carbonate horizon develops. It exists in this belt in its most faintly developed form, and under whatever conditions of topography and texture the carbonate would probably never accumulate to sufficient thickness and purity for the formation of a caliche.

On the basis of the facts thus far accumulated in the study of American soils we seem justified in concluding:

1. That well-defined carbonate caliche or hardpan develops under the soils of the chestnut-colored soil belt and of all the soil belts developed under lower rainfall than that of the chestnut-colored belt.
2. Within the belts where it may develop it forms
 - (a) On the brinks of canyons and valley slopes extending back from the outcrops beneath the soils of the uplands, at most, only a few yards.
 - (b) Under gravels, sands, and other coarse-textured soils.
 - (c) At very shallow depths under soils of heavier texture.

The caliche seems to be essentially the same soil feature as the soft horizon of carbonate material and differs from the latter only in purity and amount present. Where the soil is porous and open to the

access of air, it will collect in large amount. In places also like outcrops on valley walls or slopes where seepage tends to accumulate and be evaporated there will be rich accumulations of soluble materials. Where, on the other hand, the soil texture is heavy and water does not evaporate rapidly and the air does not gain ready access to the soil, a few inches below the surface the accumulation will be slow and will be mixed with the clay and not be formed in a pure state.

The accumulation is the product of two operations, consisting, first, of the carbonation of the metallic constituents of the soil solution, mainly calcium, through the action of the CO_2 of the soil atmosphere, and, second, of the evaporation within the soil of the soil solution, leaving the dissolved carbonates as a precipitate.

The caliche is a desert crust. It develops as a calcareous crust in regions where the rainfall is high enough to remove the highly soluble salts, or in localities within regions of very low rainfall, where, on account of the rapid surface or underground drainage these substances are removed, leaving only the less readily soluble substances, such as lime carbonate and gypsum, to accumulate along the zones where evaporation takes place.

Belts of alluvial deposits occur along the streams. These belts are extremely narrow, and some of them could be shown only by exaggerating their width. On the High Plains the alluvial soils, which are dark in color and represent material washed from the Amarillo and Richfield soils, are mapped under one head as alluvial soils, undifferentiated. In the Permian Red Beds region the alluvial soils are red to reddish brown and represent material washed from the Permian Red Beds soils (Vernon) and possibly some from the Amarillo. These soils belong to the Miller series and were mapped in two general groups as Miller sandy soils and Miller heavy soils. This was necessary, as it was impossible to differentiate the type in such small areas as they occurred.

In Dickens County an area is mapped as alluvial soils undifferentiated. The soil is not red, though occurring in the Permian Red Beds region. Some small areas of second-bottom soil in this region have been mapped as Bastrop. The subsoil has a reddish color.

CLASSIFICATION.

The processes of weathering vary considerably, and the original underlying materials differ to some extent, so that a number of soil types are found in the region. Only the larger soil areas could be shown on a map of the scale used in this survey, and the areas outlined include small areas of other types of soil. While not shown on the map, these types are described in the report under the proper heading.

The following table gives the name and extent of the different soils:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Amarillo fine sandy loam.....	1,423,872	20.4	Foard clay.....	232,704	1.9
Light phase.....	1,105,920		Miles sandy loam.....	202,752	1.6
Amarillo clay loam.....	2,343,168	18.9	Richfield silty clay loam.....	161,280	1.3
Rough broken land.....	1,158,912	9.3	Miller sandy soils.....	112,896	.9
Vernon clay.....	893,952	8.6	Foard silty clay loam.....	110,592	.9
Eroded phase.....	177,408		Brackett clay.....	110,592	.9
Vernon clay loam.....	714,240	6.4	Derby loamy fine sand.....	85,248	.7
Stony phase.....	71,424		Rough stony land.....	48,384	.3
Vernon fine sandy loam.....	760,320	6.1	Bastrop fine sandy loam.....	42,624	.3
Miles fine sandy loam.....	564,480	4.5	Alluvial soils, undifferentiated..	40,320	.3
Derby fine sand.....	188,928	4.3	Brackett fine sandy loam.....	27,648	.2
Dune phase.....	347,904		Foard loam.....	13,824	.1
Vernon very fine sandy loam...	527,616	4.3	Foard fine sandy loam.....	11,520	.1
Amarillo loam.....	387,072	3.1	Miller heavy soils.....	11,520	.1
Vernon loam.....	304,128	2.5			
Amarillo clay.....	237,312	1.9	Total.....	12,418,560	.....

SOILS FROM SANDSTONES AND SHALES.

VERNON SERIES.

The soils of the Vernon series have been formed by the weathering of the Permian Red Beds. The soils range in color from brown to Indian red, and the subsoils are chocolate brown, brownish red, or Indian red. Five types and two phases have been mapped in the Vernon series; the fine sandy loam, very fine sandy loam, loam, clay loam, and clay, the stony phase of the clay loam, and the eroded phase of the clay.⁴ The soils of this series are found in large areas throughout northwestern Texas, western Oklahoma, and southern Kansas.

VERNON FINE SANDY LOAM.

Description.—The surface soil of the Vernon fine sandy loam is an Indian-red or chocolate-brown to brown fine sandy loam or loamy fine sand about 12 inches deep. The subsoil is Indian-red, brownish-red, or chocolate-brown loam to sandy clay. The lower subsoil at 24 to 30 inches is usually calcareous and, in many places, of a yellowish-red color. In mapping this type some small areas of Vernon loam and Vernon clay loam were included.

The surface soil of the Vernon fine sandy loam is quite friable in cultivated fields, although locally it is considered fairly "tight" land. It blows some in heavy winds, but not so badly as some of

⁴ A broken phase of this soil is described in the report, but is not shown on the map.

the lighter soils. On drying in uncultivated fields the surface bakes rather hard, and in dry seasons the soil bakes slightly in cultivated fields to a depth of 2 or 3 inches. On the high smooth areas the subsoil does not always change within 3 feet of the surface, but on sloping areas the lower calcareous stratum occurs within the 3-foot section and in places near the surface.

Location.—The Vernon fine sandy loam occurs in the rolling prairies in the eastern part of the area surveyed. Good-sized bodies lie in Motley, Cottle, Knox, Haskell, and adjacent counties.

Topography.—The topography is gently rolling and in places near streams hilly. Eroded and broken areas in which cultivation of large areas is not possible are shown on the map by lines ruled over the color representing the type.

Several streams flow through the type, and, in general, the drainage is good. Small areas are slightly basinlike and have poor drainage, and here the soil is heavier and darker. The type erodes and washes badly on slopes where not protected, but many of the slopes remain in pasture.

Origin.—The Vernon fine sandy loam has been formed in the main by the weathering of sandstones of Permian age, though it seems probable that some of it may have been formed in part, so far as the sandy material is concerned, by the blowing of sandy material from areas of sand deposited along the larger streams. Good wells of water are secured over the type, but much of this water contains considerable calcium sulphate or gypsum and is locally termed "gyp water." This water is suitable for stock and is also used by people to some extent, though much of it is unpalatable.

Utilization.—The Vernon fine sandy loam is a valuable soil for the production of a number of crops. For many years it was used only for grazing cattle, being included in large ranches. The native vegetation consists of a heavy growth of native prairie grasses, of which buffalo and mesquite are the most valuable. Some sedge grass and grama grass occur. A scattering growth of small mesquite trees and some chaparral and catclaw bushes form the characteristic plants of larger growth.

A large proportion, possibly 50 per cent of the type, is now in cultivation. The soil is easily cultivated and holds moisture well. It is less subject to drifting than some of the lighter soils. The principal crops are cotton, corn, milo, kafir, feterita, sorgo, and millet. On a few farms small acreages of wheat and oats are sown. In seasons of good rainfall cotton yields one-half bale or more per acre and corn 15 to 30 bushels. The grain sorghums yield 20 to 40 bushels per acre and several tons of hay. Sudan grass, broom corn, and

emmer would doubtless yield good returns on this soil, and probably small quantities of some of these crops are now produced.

Peaches, plums, grapes, and berries do well in the small home orchards, though late freezes sometimes destroy the fruit crop. Grapes are a fairly certain crop. Small fruits and vegetables do well in the home gardens and may be produced commercially where markets can be reached.

The uncultivated land is still utilized for grazing.

The Vernon fine sandy loam sells for \$25 to \$60 an acre in improved farms and for less where unimproved.

VERNON VERY FINE SANDY LOAM.

Description.—The surface soil of the Vernon very fine sandy loam consists of 6 to 10 inches of a brown to chocolate-brown very fine sandy loam. This is underlain by chocolate-brown loam or very fine sandy loam, which normally passes at 18 to 24 inches into a reddish-yellow loam or very fine sandy loam carrying considerable grayish calcareous material. In places where erosion has removed the soil this calcareous material may occur on the surface or in the upper subsoil. The material is compact on the surface, but is friable and porous throughout the 3-foot section. The soil is characterized by its smooth feel and friable structure. The percentage of silt is relatively high in both soil and subsoil. There are included in the type some areas that in a detailed survey would have been mapped as Vernon silt loam.

Location.—The Vernon very fine sandy loam is developed in the eroded plains in Dickens, King, Motley, Cottle, Kent, Foard, and Stonewall Counties.

Origin.—The Vernon very fine sandy loam has been derived from materials coming from the Permian Red Beds and probably represents areas where the original formation consisted of clay and shale and fine-textured sandstone or sandy clay; that is, finer textured material than that giving rise to the Vernon fine sandy loam.

Topography.—Some of the Vernon very fine sandy loam is gently to moderately rolling, but the greater part is rolling to hilly. When viewed at a distance the rolling and hilly country appears as smooth slopes, but it is dissected by numerous gullies or dry stream courses, having narrow beds with steep and, in many places, vertical walls. (See Pl. V, fig. 2.)

Though much of the surface is cultivable, the eroded and gullied condition makes farming over large bodies of the type impossible. Areas of this sort are indicated on the map by ruling. The friable porous structure of much of the soil is conducive to erosion, which is active even in the gently rolling country where not protected by sod

or careful handling of cultivated fields. Drainage is good throughout the type and excessive in the rolling country.

Utilization.—The Vernon very fine sandy loam is used principally for grazing. The hilly and rolling country is all in pasture. Small bodies of the gently rolling areas are under cultivation. The native vegetation consists of mesquite grass, buffalo grass, and many kinds of coarse grasses, weeds, including wild sunflower, and a scattering growth of mesquite trees. Buffalo grass, a very nutritious and valuable grazing plant, is the most abundant grass on this type.

The small areas under cultivation are used for producing the general farm crops of the region, milo and cotton predominating. In favorable seasons fair yields of all crops are obtained. The soil in smooth areas is well suited to the production of sorgo, the grain sorghums, cotton, and corn. It is a good vegetable soil, and the common fruits do well. Grapes would do well, judging from the results of small plantings. Over much of the type erosion is so active that it would be better to use the land only for pasture. Erosion can be prevented or retarded to some extent by maintaining a good grass cover. This is difficult, however, in a region where dry years at intervals interfere with the growth of grasses. Sweet clover sowed in the eroded pastures would probably supply valuable forage and tend to check erosion.

VERNON LOAM.

Description.—The surface soil of the Vernon loam is a brown to chocolate-brown loam, with a depth of 6 to 10 inches. It is underlain by chocolate-brown, Indian-red, or yellowish-red loam, fine sandy clay loam, or clay, which commonly passes at about 20 to 30 inches into reddish-yellow friable fine sandy clay, containing in many places considerable calcareous material. On eroded slopes, where the surface material has been removed, layers of caliche outcrop in some places, and fragments of this material are scattered over the surface and throughout the 3-foot section. The surface of this type is compact in uncultivated areas, and in washed places it approaches a clay loam in texture. Bodies of this soil in King, Cottle, Dickens, and Garza Counties at one time probably consisted of very fine sandy loam, the former surface material having been partly removed by the action of wind and water, leaving material with the texture of loam.

Location.—The Vernon loam is found in the eroded plains or low-plains country. It is developed in comparatively small scattered bodies in Dickens, King, Cottle, Garza, Motley, and adjacent counties. The largest area lies to the east and north of Dumont in King County.

Origin.—The Vernon loam has been derived from the weathering of the Permian Red Beds. Like the Vernon very fine sandy loam,

this type probably represents areas where the original material consisted of finer textured sands, clays, and shales than those giving rise to the Vernon fine sandy loam. The calcareous substratum in this soil probably represents accumulation by soil water through processes of solution and evaporation.

Topography.—Over the greater part of the type the topography is gently rolling to rolling, but there are some small bodies of gently undulating to nearly level country. In the gently rolling country the drainage is good, while in the rolling areas it is excessive. The open, porous structure of the soil causes it to erode rapidly in the rolling areas if not protected by sod or if great care is not used in cultivation. In Cottle County a body of this soil has been so badly eroded as to be unsuited to cultivated crops. This condition is indicated on the map by ruled lines.

Utilization.—A large part of the gently rolling land of the Vernon loam is under cultivation, but the greater part of the rolling country is in pasture. The cultivated area is used successfully for the production of the general farm crops of the region. Cotton and milo are the principal crops. In good seasons cotton yields from one-half to 1 bale, and milo 1 to 2 tons of heads per acre. In very dry seasons yields of all the crops are low, and sometimes a failure. All the fruits and vegetables that succeed in this region do well on this soil. Mesquite, buffalo, and other grasses which grow naturally on this soil furnish good grazing. On account of the ease with which this soil erodes, the more rolling areas should be left in pasture.

Smooth areas of this land which are in good farms sell for \$25 to \$50 an acre. Those suited only for pasture bring considerably less.

VERNON CLAY LOAM.

Description.—The surface soil of the Vernon clay loam consists of about 8 inches of brown or chocolate-brown to brownish-red clay loam. This is underlain by brownish-red and Indian-red clay, which becomes more friable and often specked or streaked with whitish lime material at depths of 15 to 20 inches. The lower subsoil is a yellowish-red or buff calcareous friable clay. In Garza County and some other sections the soil often has a surface veneer of fine to coarse sand and waterworn gravel, and, especially after rains, seems lighter in texture in places than it really is. This light surface layer grades quickly into heavy clay, and the material turned up and mixed by the plow has a clay or sandy clay loam texture. Variations occur where the soil is only 4 to 6 inches deep. Elsewhere it is quite silty and friable, being a silty clay loam with some included small bodies of silty clay. In some places the silty soil extends to a depth of 12

inches or more. There are included areas of Vernon clay, Vernon fine sandy loam, Vernon loam, and Foard clay loam.

Location.—The Vernon clay loam occurs in every county lying in the low-plains section of this area. The largest bodies lie in Dickens, Kent, and Knox Counties.

Topography.—The surface of the larger part of this type is gently undulating to slightly rolling. On some divides it is nearly level, and along streams it has been dissected by branches which give good surface drainage over most of the areas. Only in a few small patches in flats does water stand after rains. A relatively small proportion of the Vernon clay loam is so dissected by streams or gullies as to be unfit for farming as generally practiced in this section. The more important of the very hilly and eroded areas are indicated on the map by parallel cross lines. Practically none of this rougher land is farmed, but it has a value of \$10 to \$15 an acre for pasture.

Origin.—The Vernon clay loam has been formed by weathering from the Permian Red Beds strata, consisting mainly of heavy Indian-red clay and shale and more or less brownish sandstone with thin beds of limestone. The lighter surface soil is due in part to the coarser texture of the original rocks and in part to the admixture of sands washed or blown over the surface.

Vegetation.—The natural growth on the Vernon clay loam was formerly a scattering of medium-sized mesquite trees and a growth of mesquite, buffalo, and other grasses. In many places there is a thick growth of broom weed. Many weeds appear at different seasons, such as plantain, daisies of many varieties, and a purple-flowered thistle which grows on the slightly sandy areas.

Utilization.—it is estimated that 25 to 30 per cent of this type is under cultivation, although in some localities the proportion rises above 50 per cent. Large areas in ranches could be easily farmed, having a favorable topography and being well located. Cattle are practically the only kind of live stock raised, horses and sheep being raised in small numbers only. Fifteen acres of range per animal was the usual allowance when the native grasses were thicker, but much more land is probably needed now, as the grazing has deteriorated in places because of the encroachment of weeds, which are said to be more abundant than formerly. Periodically dry years seriously diminish the grazing value of the native grasses.

The Vernon clay loam is locally known as "tight land." Its texture is such that it can be cultivated and kept in fairly good tilth, but it is not porous enough to absorb all the water which falls during heavy showers, as the sandy soils do. Because it stores less water, crops do not withstand drought as long as on the more sandy soils, although in favorable seasons the yields are larger. The prin-

cipal crops on this soil are cotton (Pl. VI) and milo, either of which may locally become more important than the other. Wheat is sown largely in some seasons. Often it is seeded for winter pasture, and if the season is favorable it is allowed to mature for grain. Feterita and kafir (Pl. VII) are grown for both grain and forage. Sorgo is also an important forage crop, averaging 4 or 5 tons of fodder per acre. Some corn is grown on Vernon clay loam in Kent County and a few other localities. The oat crop is of minor importance, although a fairly successful one.

Crop yields depend more on the rainfall than on any other one factor, and the very low production in droughty seasons is not a measure of the strength of this soil. When rainfall is adequate wheat yields from 10 to 30 bushels per acre. The season of 1919 was quite favorable and 20 to 25 bushels per acre was commonly obtained. The average yield of cotton is hardly more than one-third bale per acre, although the better farmers in good seasons in their best fields sometimes produce more than a bale. The grain sorghums ordinarily average about 30 bushels per acre. With adequate rain they often produce 40 to 60 bushels per acre. Corn makes about 20 to 25 bushels per acre when successful, but it is a very uncertain crop, owing to its susceptibility to injury by dry weather. Cowpeas do well in the small areas grown. They should be more extensively planted. Other crops grown in patches on this type are alfalfa, Sudan and Johnson grasses, peanuts, and garden vegetables. These all do well when the seasons are favorable.

Unimproved land and range land of this type sells for \$15 to \$25 an acre, and improved farm land for \$25 to \$60 or more, according to the improvements and location. The eroded broken land is of value principally for grazing. The more nearly level land can be made much more valuable by bringing it under cultivation and making improvements.

Vernon clay loam, stony phase.—There are a number of areas of Vernon clay loam in the northeastern part of this reconnaissance survey in which from 25 to 50 per cent of the surface is of a rather stony nature, owing to outcropping of gypsum rock and limestone. These stony areas lie on slopes and ridges. There are also many smooth areas which have only a few inches of soil over the rock stratum. Probably some of these areas could be cultivated, but more or less gypsum would be turned up by the plow. In some of the associated smooth areas the rock lies 10 to 30 inches below the surface. There are places where the land is of a rather rough, stony nature in areas of a square mile or more. The stony areas have a thin covering in many places of Indian-red, brown, or white loam or clay loam soil.

The areas of this phase are rolling to hilly, with some valleys and smooth country between. The surface has good to excessive drainage.

The main bodies of the phase are located in Hardeman and Foard Counties.

The soil of the phase has been derived from the weathering of the Permian Red Beds, and the somewhat rough topography is due to surface erosion. The phase is cultivated to only a very slight extent. It is utilized principally for grazing stock. It supports a good growth of native grasses, of which buffalo and mesquite are probably the most valuable. A heavy growth of broom weed is usually present. Where very stony this phase supports little grass, some weeds, and a scattering of catclaw bushes. Small mesquite trees grow scatteringly and also a few hackberry trees.

This land in large bodies sells for \$20 to \$35 an acre.

VERNON CLAY.

Description.—Prevaillingly the surface soil of the Vernon clay consists of 8 to 10 inches of dark-reddish or chocolate-brown clay. The subsoil is a brownish-red or Indian-red heavy clay, which changes in color to slightly yellowish red and is calcareous at depths of 20 to 24 inches, as shown by white streaks of limy material and some concretions. This is an extensive type on the eroded plains and as mapped includes a number of variations in color and texture. There are also inclusions of small bodies of other types of soil.

Some of the areas in Garza County consist of very heavy Indian-red clay extending from the surface to a depth of 3 feet or more. This is very plastic when wet and bakes hard and forms large deep cracks on drying. It is not cultivated in Garza County, but is used chiefly for pasture. Salt grass is a characteristic growth. The ground is bare in places and shows some white incrustations. In a more extensive variation occurring in Foard, Hardeman, and Cottle Counties the soil does not crack badly and is more easy to cultivate, because the surface to a depth of about 2 to 4 inches consists of silty clay or silty clay loam. In the western parts of Hardeman and Foard Counties the Vernon clay includes numerous small areas where gypsum rock comes nearly or quite to the surface or where narrow erosional belts occur between bodies of land which have a few feet difference in elevation, so that the land is often cut into rather irregular fields. In this same region there are small areas of Foard clay and Vernon clay loam. A transition from dark clay to very shallow stony soil sometimes takes place in a very short distance, but as a whole the areas consist of Vernon clay. In the eastern part of Hardeman, Foard, Haskell, and King Counties the Vernon clay areas are in places an unusually dark chocolate brown,

tending in color toward the Foard clay, small areas of which are included.

Location.—The Vernon clay is mapped in every county of the rolling eroded-plains section except Motley. It is quite extensively developed in Garza, Hardeman, Foard, Cottle, Haskell, and Stonewall Counties, and to a lesser extent in Knox, King, and Kent Counties. It is a very important type.

Topography.—Typically the surface is gently undulating to very gently rolling. In Garza County, and to a lesser extent in Hardeman and Foard Counties, it is broken, and there are buttes or mesas where parts of the type lying at different elevations are separated by steep and very narrow slopes. The upper levels are held up or protected from erosion by strata of harder rocks which outcrop along the slopes, while the underlying red or red and gray clay are eroded almost vertically down to the flat several feet lower. Practically all parts of this type have good surface drainage through a network of small streams and dry channels, except on the flattest divides. As a rule, stream dissection has not rendered any considerable areas of the type unfit for cultivation. Most of the areas are well adapted to the use of tractors and other farm machinery.

Origin.—The Vernon clay is derived from the weathering of the heavy Indian-red calcareous clays of the Permian Red Beds. To a small extent strata of drab and gray clay, brownish sandstone, and white or gray hard rock consisting of carbonate and sulphate of lime have contributed to its formation.

Utilization.—At present the most characteristic natural growth on the Vernon clay consists of a dense covering of broom weed, about 2 feet high, with a scattering of mesquite trees from 6 to 12 feet high. Beneath the covering of weeds there is a thin stand of the native grasses, such as mesquite, buffalo, and grama grasses. Sunflowers grow tall and rank along the roads and on idle land once in cultivation.

Practically all this soil in Garza, King, and Knox Counties is used for grazing, and for that purpose is held at \$10 to \$15 an acre in the large ranches. It has a higher value when used for pasture in the farming districts. About 50 to 60 per cent of the type in Hardeman, Cottle, and Foard Counties is now under cultivation. The principal crops are wheat, grain sorghums, sorgo, and cotton. Wheat and cotton are cash crops; the sorghums are grown chiefly to furnish feed for the work stock and cattle during the winter, but some grain is sold. This type is not considered very well adapted to corn.

The Vernon clay is a strong soil and produces well when there is an average rainfall. In wet seasons it surpasses many of the lighter types of soil, but it is less productive in dry seasons. As

a rule it is not injured by blowing or by washing, although there are small included areas of an eroded phase.

During extreme droughts the yields of all crops are very low, and they are sometimes left unharvested, but in average favorable seasons wheat will produce from 10 to 18 bushels per acre. In 1919 yields of 20 to 30 bushels were commonly reported, with an average of about 24 bushels. Cotton will normally give one-third bale per acre under average conditions. With the moist conditions of 1919 cotton was making a very vigorous growth of stalk and gave promise of one-half to 1 bale per acre in many fields. Cotton matures several weeks later on Vernon clay than on the sandier soils. Several different grain sorghums are grown on this type, all of them producing heavy yields of fodder and large heads of grain in 1919. In different localities a preference for milo, kafir, or feterita is shown. Both the standard and dwarf varieties are common. Dwarf red or yellow milo were seen in all sections, the fields having a uniformly good appearance. Taller varieties are not so dependable, although they yield more forage. Some farmers grow the white varieties of kafir and milo. Nearly all farms have patches of sorgo for forage. This crop is usually cut and stacked near the barns for winter feeding. It is often used to fill silos, as it will not keep so long in the stack as kafir. Average yields of 5 or 6 tons of sorgo per acre are obtained, but in years of abundant rainfall it may yield 10 tons or more.

The average yields of the sorghum grains is a little less than 30 bushels per acre. In dry seasons milo and feterita usually yield better than kafir, but the latter surpasses them in wet years. In the favorable year 1919 many fields of these grains produced 45 bushels per acre.

A few small fields of oats have been sown on this type with fair results. Small patches of Johnson grass and Sudan grass were observed. These crops do well if the rainfall is sufficient. They are cut for hay and yield about one-half to three-fourths ton per acre. Alfalfa has also been tried on this type, but made only fair yields without irrigation. Garden crops are produced for home use. When the ground is given special attention good yields of most vegetables are obtained. Irish potatoes give rather indifferent returns.

In the present weedy condition of the range it would seem that the pasturage would be better for sheep and goats than for cattle. In the farming sections the practice of summer fallowing and other dry-land farming methods would give better and surer yields of wheat and other crops. While the soil is better adapted to small grain than to some of the intertilled crops, much of it, especially the areas with a rather friable surface, might be more carefully culti-

vated and kept in such a state of tilth that the dwarf grain sorghums would be surer to yield well, even in dry years.

Tractors are used in cultivating this land, especially in breaking, disking, and harrowing the soil for wheat. Since most of the wheat is shocked, the plowing does not begin until after thrashing, although some farmers head and stack the grain and have the ground clear for plowing immediately after harvest. More disk than moldboard plows are used. A gang of two or three plows is drawn by a small tractor or by a 6-horse team, while the larger tractors pull five to eight plows. Large-sized drills, binders, headers and other machinery are commonly used. In some cases trucks are employed in hauling grain to market.

While small parts of this type may well be kept in pasture, it has too high a value to be left in the range. This is especially true since the grass has been crowded out by weeds and the carrying capacity of the land considerably reduced. Formerly an allowance of 15 to 20 acres per animal was considered ample. The same area of land in sorghum crops should carry more cattle. When the country becomes more thickly settled and roads to markets are improved, large areas of Vernon clay now used only for grazing will doubtless be cultivated.

Areas convenient to good transportation and markets sell for \$30 to \$60 an acre, depending on improvements. Near towns the prices are somewhat higher.

*Vernon clay, broken phase.*⁵—In Stonewall County around Aspermont there are several large areas of Vernon clay classed as a broken phase. The soil section here is practically identical with that of the typical soil. It consists of chocolate-brown to Indian-red heavy clay extending to depths of 3 feet or more. It lies near the larger streams and is dissected by a network of branches and draws which head in it. Although it is eroded by these streams, the land is not subject to sheet erosion, nor it is bare of vegetation like the eroded phase of the Vernon clay, being generally covered with a thick growth of weeds, a sparse stand of mesquite and buffalo grasses, and a scattering of mesquite trees. This phase is devoted almost entirely to pasture. It affords better protection from the weather in winter than the more nearly level Vernon clay.

Vernon clay, eroded phase.—The Vernon clay, eroded phase, represents a surface condition rather than a soil. It is really unweathered and partially weathered parent soil material. It consists of Indian-red clay and clay shale of the Permian formation, usually interbedded with thin layers of gypsum rock, fragments of which, with some waterworn quartz gravel in places, are scattered over the surface.

⁵ This phase not shown on map.

Location.—This phase occurs between the steep breaks and the bottoms of some of the larger streams of the area. The largest bodies are in Knox County along the valleys of the North and South Forks of the Wichita River.

Topography.—The Vernon clay, eroded phase, occupies nearly level to gently rolling and rolling country sloping streamward. The run-off is excessive, as the nonporous heavy clays and shales prevent absorption of water.

Origin.—The eroded phase has been formed entirely by erosion of the Permian Red Beds. The water from the steeper adjacent slopes passing over the surface has continually cut the country down to a lower level. On the gentle slopes the type is dissected by an intricate system of gullies having very narrow tortuous channels with perpendicular walls. On the more nearly level country the water spreads out, and definite stream courses are usually lacking. This phase has been formed by the exposure of the clay by erosion and the washing away of the soil. The surface of the more level areas is dotted by numerous small mounds. These mounds support one or more scrub cedar trees (juniper) or mesquite bushes and a few coarse weeds, which have protected them from erosion. The intermound spaces are generally bare of vegetation. This condition is no doubt due to the presence of large quantities of calcium sulphate and to the unfavorable mechanical condition of the freshly exposed clay. Over the type as a whole erosion is active, keeping pace with the cutting down of the stream valley below.

Utilization.—The Vernon clay, eroded phase, supports a sparse growth of stunted cedars, mesquite bushes, and coarse weeds, with little or no pasture grass. The type is nonarable and furnishes very poor grazing.

Land of this type sells at \$3 to \$8 an acre.

FOARD SERIES.

The Foard soils are dark brown to black, and the subsoils are yellowish brown or grayish brown to dark ashy gray or black. The fine sandy loam is lighter colored than the clay, which ranges to black. The heavier types characteristically have tough clay subsoils. The material is derived from the Permian rocks. The surface is flat or level, and the drainage is not so good as that of the associated Vernon soil. The series differs from the Kirkland in having a calcareous subsoil.

Four types were mapped, the fine sandy loam, loam, silty clay loam, and clay. The last two named types cover much the larger area included in the series.

FOARD FINE SANDY LOAM.

Description.—The surface soil of the Foard fine sandy loam consists of 4 to 6 inches of a grayish-brown or brown fine sandy loam. The upper subsoil is a brown or chocolate-colored heavy silty clay containing some fine sand. This passes at 15 to 20 inches into a brownish-gray, grayish-yellow, or yellowish-gray heavy silty clay mottled in most places in the lower part of the section with lighter gray and rusty brown. In places the lower subsoil is gray or grayish brown without mottlings. Calcareous material is nearly everywhere encountered at depths of 15 to 20 inches. The type is somewhat lighter colored than the heavy members of the series.

Location.—The Foard fine sandy loam is developed only in small bodies associated with the Vernon fine sandy loam in the extreme eastern counties. In Knox County the largest area lies in the southeastern part near Munday.

Origin.—Like the other types of this series, the Foard fine sandy loam has been derived from the weathering of the Permian formations. Originally it was probably a clay or a silty clay loam, but lying a little lower and being surrounded by the Vernon fine sandy loam, the action of the wind and of water draining from the adjacent slopes has produced a sandy covering.

Topography.—The Foard fine sandy loam occupies flat to nearly level country. Lying a little lower than the surrounding country, the soil receives run-off from the adjacent slopes and remains saturated for some time after heavy rains. In a country of heavy rainfall this condition would prove a serious menace to growing crops, but in this region of comparatively light rainfall it is more often beneficial than injurious.

Utilization.—The greater part of the Foard fine sandy loam is under cultivation. Cotton, milo, corn, and sorgo are the principal crops. The yields of cotton and milo are about the same as on the Vernon fine sandy loam. The water-holding capacity of this soil makes it well suited to the growing of corn and sorgo, and at the time of the survey there was a greater acreage in these two crops on this soil than on the surrounding Vernon fine sandy loam. Corn produces from 15 to 40 bushels, with an average of about 20 bushels per acre. Sorgo yields from 4 to 10 tons of forage, with an average of about 5 tons per acre. Small patches of sweet potatoes and garden truck are grown on this soil and it is probable that these crops could be grown on a commercial scale if markets were convenient.

Land of this type sells at the same price as the surrounding Vernon fine sandy loam.

FOARD LOAM.

Description.—The surface soil of the Foard loam, to a depth of about 6 inches, is a brown or grayish-brown to dark-brown loam containing a high percentage of silt. The subsoil is a brown or grayish-brown heavy, compact silty clay loam, passing at about 15 to 20 inches into gray, ashy-gray, or brownish-gray heavy clay which contains a noticeable quantity of grayish chalky calcareous material and lime fragments and is sticky when wet.

Location.—This type is of small extent and occurs only in the easternmost counties of the area. In Knox County the two main bodies of this soil lie to the east and northeast of Vera.

Topography.—The Foard loam occupies nearly level to gently sloping country and lies a little lower than the surrounding Vernon soils. The surface drainage is fair to good, but the heavy structure of the subsoil does not permit of the rapid downward movement of water.

Origin.—Like the Foard silty clay loam, this soil has been derived from the weathering of the shales and clays of the Permian formation. Originally the surface probably consisted of clay or silty clay loam and its loam texture is probably due in great part to the action of sand blown from the adjoining sandy soils.

Utilization.—All this type of soil is cultivable, and practically all is now used in growing the general farm crops of the section. The yields are as large or possibly average a little larger than on the Foard silty clay loam. The soil is easier to work and more retentive of moisture than the silty clay loam.

Lands of this type sell at \$20 to \$50 an acre, according to location and improvements.

FOARD SILTY CLAY LOAM.

Description.—The surface soil of the Foard silty clay loam consists of 6 or 8 inches of a brown, dark-brown, or dark grayish brown heavy silt loam to silty clay loam. The subsoil in the upper part is a brown, reddish-brown, or chocolate-brown heavy compact clay. This usually passes at 18 to 24 inches into a brownish-gray or yellowish-gray heavy clay which contains calcareous material. The close structure and heavy texture of the soil causes it to crack on drying, but if plowed under right moisture conditions a good seed bed is obtained. As mapped, this type includes small areas of Vernon loam and gradations between the two types. These could not be shown separately on account of the small extent and the almost imperceptible gradation from one to the other.

Location.—The Foard silty clay loam occurs principally in Knox and Haskell Counties. It is a rather extensive and important soil

type. It is associated with the Vernon soils and occupies the flat or level divides between stream valleys. In Knox County the largest bodies are found in the northeastern part, between the North and South Forks of the Wichita River. Other large areas are located in the north-central, western, and southeastern parts of Haskell County.

Topography.—The Foard silty clay loam occupies flat, very gently undulating to very gently rolling country. The surface drainage over most of the type is poor, though on the gentle slopes the run-off is sufficient to give fairly good drainage. The heavy, compact structure of the subsoil does not permit of rapid underdrainage, and the surplus surface water either runs off slowly or is dispersed by evaporation. In a country of heavy rainfall this lack of drainage would prove a serious menace to growing crops, but with the light rainfall of this region it does not often interfere with their profitable production, and indeed is a favorable rather than an adverse condition. Small streams, or draws, head near low areas of the type and assist the natural drainage to some extent. There are no streams passing through this type.

Origin.—The Foard silty clay loam has been derived from the weathering of Permian Red Beds and probably represents areas where the original material contained more silt and clay than those giving rise to the lighter textured soils of the region. The darker color of the Foard soils is probably due to the inadequate aeration and drainage and a greater accumulation of organic matter than in the Vernon soils. It is probable that some of the Permian material from which this soil was formed was not red.

Utilization.—All of the Foard silty clay loam is tillable. It is mostly in farms and is used to produce a number of crops. Until recent years this soil was used almost entirely for grazing purposes, though probably more than 50 per cent of the type is now under cultivation. The soil supports a good growth of grasses, consisting principally of buffalo grass (locally called mesquite grass). There is also a scattering growth of small mesquite trees, with various kinds of weeds and coarse grasses. The principal crops grown are cotton, wheat, and milo, with some kafir, feterita, sorgo, and Sudan grass. In good seasons cotton yields from one-third to 1 bale, with possibly an average of one-half bale. In very dry seasons the yields are much lower. Considerable bodies of this soil were planted to wheat last year (1918). The yields averaged about 15 bushels per acre. Until the present time very little wheat has been grown on this soil. The type is a good wheat soil and in favorable seasons will no doubt give good returns. Milo yields 25 to 50 bushels per acre in favorable seasons. Kafir and feterita are not so extensively grown as milo.

Yields are possibly a little lower than for milo. Sorgo and Sudan grass are grown in small patches for hay. Yields of 2 to 10 tons are obtained, with an average of about 4 tons per acre. This soil is probably well suited to the production of Sudan grass. Oats and corn could be profitably grown in years when moisture conditions are favorable.

Land of this type sells for \$20 to \$50 an acre.

FOARD CLAY.

Description.—The surface soil of the Foard clay consists of dark-brown to black heavy clay from 8 to 20 inches deep, averaging about 16 inches. The subsoil is a dark-brown or grayish-brown heavy clay, marked or mottled with gray limy material, which also appears in the form of marly concretions. Sometimes there is so much lime as to give the subsoil a decidedly gray color, and in places where the concretions are found within 8 inches of the surface the top soil when dry has a grayish cast. The principal variations in this type consist of a somewhat lighter textured soil, approximately a silty clay loam, and of areas in which the subsoil has a slight reddish tinge, resembling the Vernon clay subsoil.

Location.—The Foard clay is mapped in a number of large areas in Hardeman, Foard, and Haskell Counties. Smaller areas lie in Stonewall and Garza Counties, and numerous spots too small to map are scattered through bodies of Vernon clay at the heads of draws.

Topography.—This type occupies flats and basins of the main divides where the surface is level to very gently undulating. The surface drainage is comparatively poor, but in this region there is little trouble from excess moisture. There are almost no depressions or "hog wallows" in which water can stand after rains. The gentle slopes and the heads of drainage ways which extend into edges of the areas usually afford outlet for the run-off. This type does not absorb rain like the sandy soils, but its level surface protects it against destructive erosion.

Origin.—The Foard soils are largely confined to the uneroded parts of the comparatively smooth areas of the Permian formations at the eastern end of this reconnaissance area. Possibly the darker color is due in part to less red in the original material from which the soil was formed. This consists chiefly of heavy clay and shale, with some seams of hard white rock composed largely of carbonate and sulphate of calcium. The level topography of this type has protected it from erosion and allowed the accumulation of humus in the surface; the limy nature of the soil is conducive to the development of a dark color. In some places the wash of surface soil from surrounding higher land has aided in the deposition of deeper and darker colluvial developments of Foard clay.

Vegetation.—The native vegetation predominating on this soil consists of a thick covering of broom weed and a scattering of mesquite trees. There is little of the original growth of mesquite and buffalo grasses left, as several years of drought have allowed weeds to take the ranges.

Utilization.—The Foard clay has been cultivated in a few places for 15 to 20 years, but most of the cultivated area is of much more recent development. It is estimated that more than 35 per cent of the type is now under cultivation, and in Hardeman County and parts of Foard County practically all the areas are farmed. Most of the land is dry farmed. The only extensive irrigation project on the lower-plains section of this area is on Foard clay in Hardeman County. Milo, cotton, and wheat are the main crops. Milo is the most reliable forage crop and is depended upon to feed the farm stock and to help carry cattle through the winter. The grain is used for work stock and in fattening rations, only the excess being sold. The average yield is about 30 bushels per acre. While the yield in dry seasons is less than on sandier soils, in favorable years, like 1919, milo does unusually well on Foard clay, producing 50 or 60 bushels per acre. It is said that it is easier to get a good stand of all kinds of crops on the Foard clay than on Vernon clay. Other grain sorghums, such as kafir and feterita, are grown successfully. Sorgo also is sown in small patches, yielding ordinarily 5 or 6 tons of forage per acre. Cotton is the main cash crop. The yields vary with the seasons, from almost nothing in droughty years to almost a bale per acre when the rainfall is ample and well distributed. The average yield over large areas is estimated at one-third to one-half bale per acre in favorable seasons. This soil is very well adapted to wheat and is largely sown to that crop in some sections. There is a fairly general practice of sowing wheat for winter pasture. If prospects are poor, it is plowed up and the land is put in another crop, but if a good stand is obtained and prospects are good in the spring, the crop is allowed to mature and is harvested for grain. Drought sometimes causes almost total failure, but when the crop is worth harvesting it yields from 10 to 30 bushels per acre. The 1919 crop was unusually good, probably averaging 20 bushels per acre. The straw stack is usually placed on idle land and used for winter feed and bedding, but some farmers follow the bad practice of burning the straw.

The Foard clay is one of the best soils of this area. All of it can and should be brought under cultivation, especially since the native grasses of the range have become so thin. It is especially well adapted to the use of tractors and other heavy farm machinery. Under the best dry-land farming methods fair yields should be ob-

tained, as the rainfall is sufficient if the moisture is carefully conserved. In one or two places it would seem that this land could be irrigated as it is at Damsite in Hardeman County.

Improved farms on Foard clay sell for \$35 to \$75 an acre.

SOILS FROM UNCONSOLIDATED DEPOSITS.

AMARILLO SERIES.

The Amarillo series consists of reddish-brown, brown, or chocolate-brown soils with a chocolate-brown to reddish-brown or red subsoil. The lower subsoil is usually calcareous and somewhat lighter in color than the upper subsoil, being a pale-yellow to buff or pinkish friable marly clay. The soils are formed by the weathering of unconsolidated deposits of the Tertiary and Quaternary ages. The sandy surface material, while originally laid down by water, has been more or less shifted by the wind. The types mapped in the Amarillo series are the fine sandy loam and its light phase, the loam, clay loam, and clay.

AMARILLO FINE SANDY LOAM.

Description.—The surface soil of the Amarillo fine sandy loam is a brown, reddish-brown, or brownish-red fine sandy loam 3 to 10 inches deep. On drying it becomes very compact and hard, but when cultivated it is quite friable. The subsoil is a reddish-brown or dull red friable clay, carrying in the lower part spots of chalky calcareous material. In places at depths below 24 inches the subsoil is a buff to brown, calcareous, very friable clay. Marl, or caliche, lies from 2 to 4 feet below the surface.

Location.—The Amarillo fine sandy loam is rather extensive in the western part of the High Plains. It occurs in a number of good-sized bodies in Hockley, Cochran, Bailey, Lamb, Yoakum, Terry, Lubbock, and Lynn Counties, and to a lesser extent in some adjoining counties.

Origin.—This soil represents the water-laid (Tertiary) deposits of the High Plains. Doubtless much of the sandy material of the surface has been placed in its present position by water, but certainly some of it has been moved onto the surface by the wind.

Topography.—The surface of this type is gently undulating to very gently rolling. Lake beds occur throughout areas of the soil as in the other Amarillo soils, and a few draws extend through the areas. The type has good drainage, as the soil absorbs the water readily. There is little run-off except into depressions within the type.

Utilization.—The soil supports a heavy growth of native grasses, chiefly buffalo and mesquite, with some grama and needle or poverty

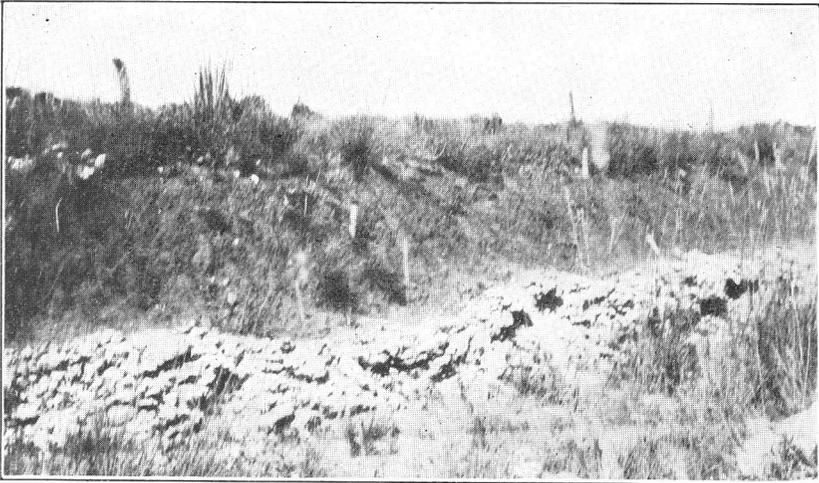


FIG. 1.—MARL, OR CALICHE, UNDERLYING THE AMARILLO FINE SANDY LOAM.

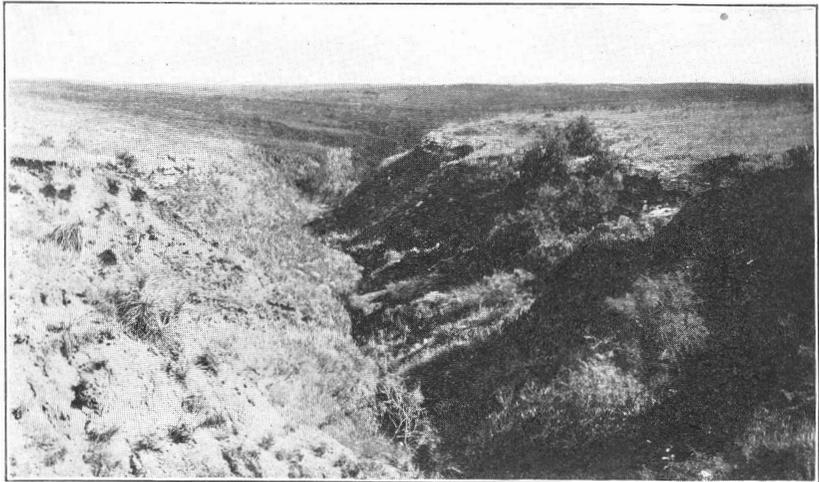


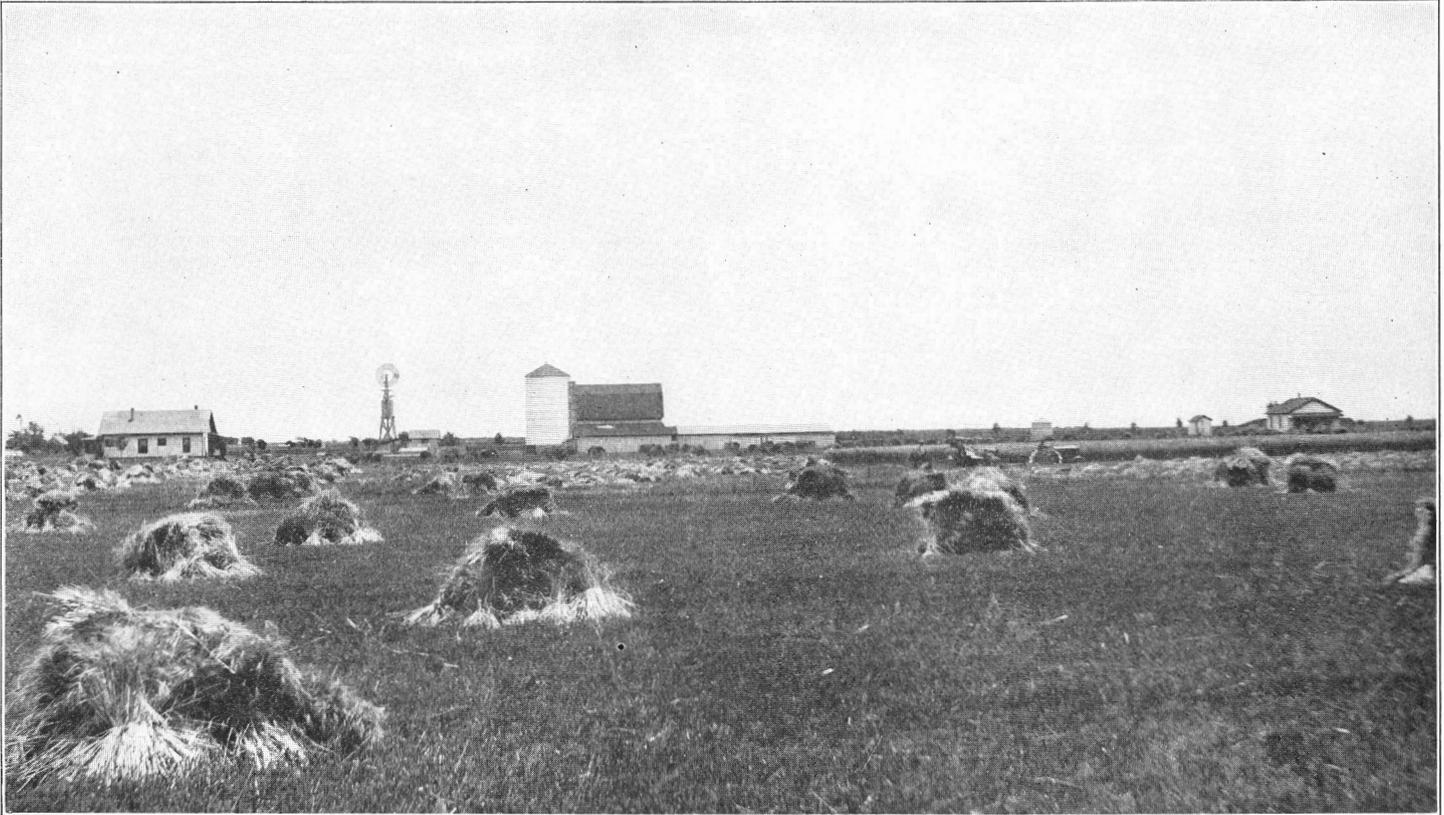
FIG. 2.—CHARACTER OF EROSIONS IN THE REGION OF THE VERNON SOILS.



COTTON ON THE VERNON CLAY LOAM, NEAR SPUR.



KAFIR ON THE VERNON CLAY LOAM, NEAR SPUR.



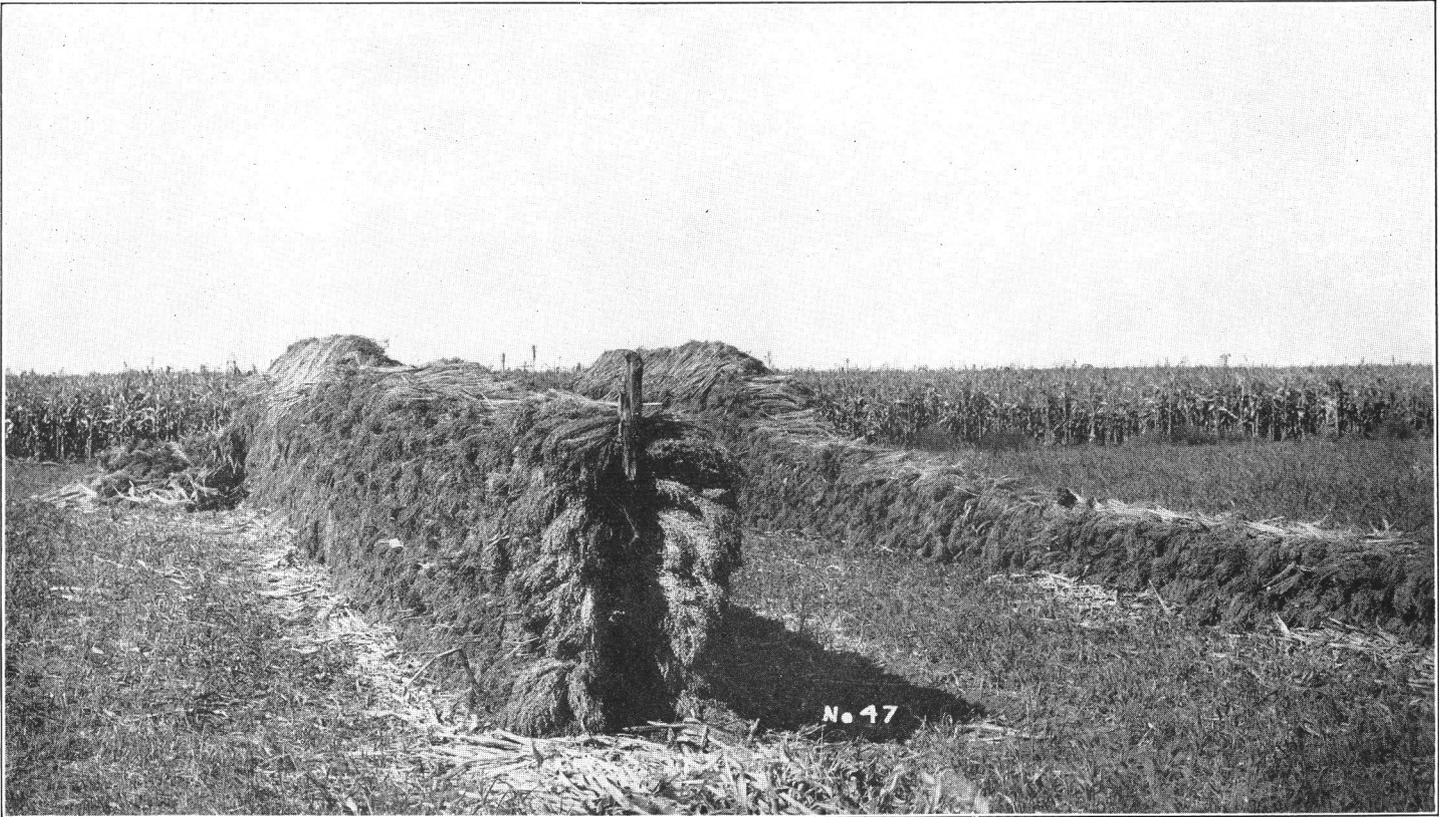
TOPOGRAPHY OF THE AMARILLO CLAY LOAM.

Note the good type of farm buildings. Silos are coming into use on many farms.



HARVESTING WHEAT ON AMARILLO CLAY LOAM, NEAR PLAINVIEW.

Tractors also are largely used in plowing this soil.



BROOM CORN ON THE AMARILLO CLAY LOAM.

The soils of the region are well suited to this crop.

grass and other species. These make excellent pasturage. A characteristic growth is a scattering stand of a small thorny shrub called catchlaw (*Acacia* sp.). Some dwarf mesquite, bear grass, and occasionally wormwood, as well as small scattered mesquite trees, grow on the soil.

A considerable part of this soil is in large ranches, but much is held by stock farmers and small ranchers in areas of several hundred to two or three thousand acres. There is a good deal of land of this type in cultivation in several of the counties, though perhaps not more than 10 per cent of the total area is used for producing crops.

It is a very productive soil, and with adequate rainfall the crops yield well. The principal crops grown are kafir, milo, cotton, sorgo, and wheat. The ranchers frequently grow the sorghums, both grain and saccharine, for feeding cattle. In good seasons kafir and milo yield 20 to 50 bushels per acre, corn 20 to 30 bushels, wheat 10 to 15 bushels, and cotton one-half to three-fourths bale per acre. Of course these yields may be much less in years that have little rain. Comparatively little wheat is grown. Fruits and vegetables do well on the soil, and produce good yields in favorable seasons.

The soil blows badly in cultivated fields during the strong spring winds, though the damage is not so great as on the lighter soils.

The land usually is listed and the seed planted in the furrows, which gives some protection from the wind. This is a very good soil, well suited to the crops grown on it. Sudan grass, emmer, barley, and feterita would yield well, though these crops have been grown very little as yet.

This land can be bought for \$20 to \$50 an acre. For land in the raw state \$20 is about the average price, while for improved land near railroads the price approximates the higher figure.

Amarillo fine sandy loam, light phase.—The surface soil of the Amarillo fine sandy loam, light phase, is a brown to reddish-brown loose, light fine sandy loam or slightly loamy fine sand. The soil is ordinarily 10 to 18 inches deep, but in some places it extends to a depth of 24 inches. Where deep the soil is very loose and incoherent, and on drying it has a distinct grayish or grayish-brown cast on the surface. The subsoil is a red to brownish-red friable sandy clay. In some places, however, the reddish-brown or buff-colored calcareous chalky material (caliche) is found at depths of 24 to 30 inches. Where the sand surface is rather deep this calcareous layer may lie 4 or 5 feet below the surface.

Location.—The Amarillo fine sandy loam, light phase, is found in the western part of the area on the High Plains. It occurs in large bodies or strips and covers the greater part of Yoakum and Terry Counties. It is also found in smaller areas in Bailey, Lamb, Hale,

Cochran, Hockley, and Lynn Counties. The type where developed most extensively surrounds the sand hills or Derby fine sand, dune phase. The phase as mapped includes small areas of various other Amarillo soils, mainly the loam and fine sandy loam.

Origin.—The Amarillo fine sandy loam, light phase, has been formed from the sandy deposits of the Tertiary. It seems altogether probable that the surface sandy material has been spread over the surface by wind action to a very considerable extent.

Topography.—The surface of this phase is gently undulating to very gently rolling. There are a number of small lake beds throughout areas of the type, some more than 100 acres in size and 20 to 50 feet below the level of the surrounding country. Some of the largest of these lakes are called salt lakes, owing to an accumulation of a whitish salt on the lake-bed surface when dry. These lakes have some water in them for a short time in seasons of considerable rainfall. A sample of the lake-bed material taken to a depth of 3 feet consisted of yellow and bluish mottled clay. An analysis by the Texas State chemist showed as follows (parts per million): sulphate of lime 5,600, sulphate of magnesia 15,657, sulphate of soda 6,733, chloride of soda 41,662, and potash (water soluble) 3,640.

The Amarillo fine sandy loam, light phase, in general, occupies a slightly higher altitude than the heavier Amarillo soils which lie to the east.

There are a few draws through the phase, but these rarely have water in them, except after unusually heavy rains. A belt not more than one-fourth mile wide along these draws is drained, however, and only a small quantity of surface water runs into them or into lakes, most of the rainfall being absorbed by the soil.

Utilization.—The native vegetation of the Amarillo fine sandy loam, light phase, consists of coarse grasses and weeds. Much of the grass is sedge grass and bluestem (*Andropogon scoparius* Michx.). There is also some Nealley's poverty grass (*Aristida nealleyi* Vasey) and grama grasses (*Bouteloua oligostachya* Nutt) and (*Bouteloua curtipendula* Michx.). Bear grass (*Yucca angustifolia*) is very abundant. A short scrubby oak is very abundant and thick over areas where the surface sand is rather deep. This is locally called shin oak and is probably *Quercus undulata*.

A large proportion of this soil is utilized for ranching and stock farming. While some of the phase is included in large ranches, a great deal of it is in smaller tracts containing from a few hundred to several thousand acres each, on which cattle are raised and grazed. Some of the grain sorghums, chiefly kafir and milo, are grown for feed. Sorgo is also used as a forage crop. Little corn is grown, and the production of small grains is not attempted, the soil being too

light for the latter crops. Cotton is grown, but on only a small acreage. The soil seems quite productive and holds moisture well, but during the heavy spring winds it blows badly where cultivated, and the young plants are covered with sand. This frequently necessitates replanting several times before a good stand is attained. The soil produces good yields of the grain sorghums and sorgo, and even in years of very light rainfall fair yields are attained. Kafir and milo return from 15 to 50 bushels per acre. Cotton in fair seasons averages one-half bale per acre.

Grasses begin growth early on this soil, and while not so nutritious as the grasses of the heavier soils, they afford valuable grazing, which in very dry seasons is better on this type than on heavier soils. The soil produces good yields of Sudan grass, although little is grown. It seems well adapted to broom corn, which is grown in small scattered patches. There is a small acreage in millet, which yields well.

The soil is well adapted to fruits, berries, and vegetables, but these are grown only in small home gardens and orchards. Grapes are especially dependable, though few are grown. Plums and peaches do well when not destroyed by late spring frosts.

This soil seems especially suitable for stock farming. It sells for \$10 to \$35 an acre.

AMARILLO LOAM.

Description.—The surface soil of the Amarillo loam consists of 6 to 10 inches of a brown to reddish-brown loam. The subsoil is in two strata, the upper a reddish-brown clay loam or clay, 18 to 24 inches thick, and the lower a brown or buff-colored friable calcareous clay, grading below into marl or caliche.

Location.—This type lies in the western and southwestern parts of the area and occupies an intermediate position between the Amarillo clay loam and the sandy types. It occurs in Bailey, Lamb, Hockley, Cochran, Lynn, and some of the adjoining counties. It is not an extensive soil type.

Origin.—The Amarillo loam is derived from the Tertiary sediments forming the High Plains. Probably the coarser material, at least in part, has been deposited on the surface by the winds. Marl or caliche lies within 2 to 4 feet of the surface.

Topography.—The surface of the Amarillo loam is gently undulating to very gently rolling. The surface drainage is generally into low areas of the type. Little of the rainfall finds its way into the small draws and lake beds.

Utilization.—This type is used for ranching, stock farming, and general farming.

AMARILLO CLAY LOAM.

Description.—The surface soil of the Amarillo clay loam consists of 4 to 8 inches of a clay loam or silty clay loam, brown, chocolate brown or reddish brown in color. The subsoil to 18 or 24 inches is a dark reddish brown, chocolate, or brownish-red clay, rather heavy and compact when dry. As a rule, the subsoil material is redder than the surface soil. In places this subsoil extends downward to a depth of 30 or 36 inches, but as a rule, at depths ranging from 18 to 24 inches, a lighter colored and lighter textured material is encountered, which extends downward for many feet. This lower subsoil is a buff to pinkish-brown clay containing a considerable proportion of lime nodules and white chalky material, which grades with depth into marl or caliche. The surface soil packs rather hard on drying, but if cultivated when moisture conditions are favorable it becomes very friable and loamy.

Location.—The Amarillo clay loam occurs in large bodies throughout the northern part of the High Plains section of the area. It comprises the greater part of Floyd, Crosby, and Hale Counties, with large areas in the adjoining counties. With the exception of the Amarillo fine sandy loam and its light phase, this soil is the most extensive type in the area.

Included with the type are small areas of Amarillo fine sandy loam, Amarillo loam, Amarillo clay, Brackett clay, Randall clay, and Richfield silty clay loam. The area of the last is considerable. In the western part of Yoakum County stony material occurs on the surface or near the surface, consisting of hardened fragments of the chalk substratum which here lies near the surface.

Topography.—The topography of the Amarillo clay loam is flat to gently undulating. (Pl. VIII.) The surface is very uniform and to the eye appears to be level, though there is a very gentle slope to the southeast. On the eastern side of the High Plains the type is bounded by the belt of Rough broken land that leads down to the Permian Red Beds area. On the west it merges into the sandy soils of the series, which are slightly higher than the main body of the Amarillo clay loam. Throughout the areas of the type there are many small lake beds lying from 5 to 25 feet below the surrounding surface, and ranging in extent from a few to more than a hundred acres. These lake beds are dry most of the time, but in seasons of considerable rainfall they contain water for several months. A part of the type, probably not over 20 per cent, drains into these lakes. A few shallow draws or streams of intermittent flow extend through the large areas of the type, but these have no small tributaries, and very little of the surface drainage enters them. Thus the greater part of the rain water is absorbed by the soil.

A good supply of excellent underground water is found everywhere on this soil at depths ranging from 50 to 200 or 300 feet. Water is pumped from these wells by windmills. It is used to some extent for irrigation in the belts where the water-bearing strata lie at comparatively shallow depths.

Origin.—The Amarillo clay loam has been formed by the weathering of the Tertiary deposits which cover the High Plains. The lighter texture of the surface soil is due to the leaching effects of rain water and the darker color is due to the presence of organic matter.

Vegetation.—The Amarillo clay loam supports a heavy growth of short native grasses, chief of which is buffalo grass. Some grama grass, mesquite grass, and other grasses also grow in the pastures. The turpentine weed (*Gutierrezia sarothrae*) is abundant in places. In cultivated areas the Russian thistle is abundant and troublesome. The blue weed (*Helianthus ciliaris*) is an especially serious pest in cultivated fields where it has been allowed to become abundant and its eradication is difficult. These weeds attain their best growth in the lower areas and depressions.

Utilization.—There are considerable areas of the Amarillo clay loam in cultivation. Most of the cultivated land is in farms situated within a few miles of railroads. In more remote sections farms are less common and much of the land is used for ranching. On many of the ranches, however, a considerable acreage is devoted to the production of feed for the cattle. Additional areas of this soil are being broken for cultivation every year. It is very productive and with good rainfall high yields are obtained, while even in years of light rainfall drought-resistant crops, such as the grain sorghums, yield some feed.

The important crops on this soil are milo, kafir, feterita, sorgo, and wheat (Pl. IX). Corn, millet, oats, cotton, cowpeas, broom corn (Pl. X), and alfalfa are crops grown at present on smaller acreages. Sorgo yields 3 to 8 tons of forage per acre and kafir and milo yield 20 to 50 bushels of grain per acre. Feterita yields slightly more than kafir or milo, but as yet is not grown so extensively. Sorghums are the most dependable crops grown on this soil. In seasons of favorable moisture conditions corn yields 25 to 50 bushels per acre, but not much is grown. In good seasons wheat yields 15 to 40 bushels per acre; in dry seasons the crop may be a failure. Oats are not grown to a great extent. When the rainfall is sufficient alfalfa does well. The altitude is rather high for cotton. It is grown extensively as far north as the southern to central parts of Hale and Floyd Counties, but north of this the growing season is generally too short. The soil is also well adapted to the produc-

tion of barley and emmer, but as yet these crops occupy only small acreages. Small fields are planted to broom corn. The crop makes a satisfactory growth and with the favorable climatic conditions is easily cured. Experiments have shown that sugar beets may be grown successfully on this soil when the supply of moisture is sufficient. All or most of these crops have been grown under irrigation and large yields obtained. Of course, it is rather expensive to irrigate land with pumped water, but with proper management it would seem that much of this land could be irrigated profitably. Some farms on this soil are now irrigated.

There are several very large ranches on the type and a great many small ones on which the production of beef cattle is the chief industry. On many ranches sheep are raised, the larger flocks containing several thousand head. Hogs do well on the type, especially when alfalfa can be grown. Under irrigation 4 or 5 tons of alfalfa may be produced to the acre. Vegetables grow well on this soil, and a small garden is maintained at every farm house or ranch. Excellent yields of all kinds of vegetables are obtained, especially where the gardens are irrigated.

All fruits and berries grow well on this soil, but climatic conditions make their production uncertain. Grapes are fairly dependable. Almost every farm has a small orchard. In extremely dry seasons fruit trees die unless irrigated.

The Amarillo clay loam ranges in price from \$30 to \$75 an acre, depending on the location and state of improvement.

Agricultural methods.—Land for wheat is prepared in the summer as early as possible. Some double-disk the land 5 or 6 inches deep. Then it is partially smoothed with a go-devil cultivator. Often the land is flat-broken in the summer 4 to 6 inches deep and double-disked afterwards. It is preferable to plow the land as soon as possible in the summer in order to store moisture from the summer rains. Wheat preferably is sown about the middle of September. It is harvested the middle or latter part of June. Some spring wheat is sown, and in favorable seasons does well, though it is very susceptible to rust. It is sown in February and harvested early in July.

Sometimes wheat is drilled in on the stubble of row crops without plowing the land. Turkey wheat is the variety grown principally. For the row crops, kafir, milo, feterita, and corn, the land is commonly double-listed in March, or late in the fall if possible, and the seed is planted from the middle of April to late in May, or sometimes later. These crops are cultivated three or four times.

Some summer fallowing is done, and the results have been very good. The land is plowed and given frequent shallow cultivation, reducing loss of moisture by evaporation and by transpiration by

weeds and other vegetation. Crops are planted the following year. As much as 25 or 30 bushels of wheat per acre has been obtained in very dry seasons where this method has been followed.

AMARILLO CLAY.

Description.—The surface 4 to 6 or 8 inches of the Amarillo clay is a dark-brown or dark chocolate colored heavy silty clay or clay. This is underlain by a reddish-brown or brownish-red compact clay, which in places continues to a depth of 3 feet or more without change, but which commonly grades at depths of about 18 to 24 inches into a lighter colored and more friable clay, carrying varying quantities of calcareous material. The soil is heavy and sticky when wet, but crumbles on drying and is easy to work if plowed when moisture conditions are right. The uncultivated surface is very compact and hard. Included with this soil are areas of Richfield silty clay loam and Amarillo clay loam, too small to separate on a map of the scale used in the present survey. In places the surface soil resembles the Richfield, but the subsoil has the color and other characteristics of Amarillo material.

Location.—The Amarillo clay is found only on the High Plains, the most important area lying on the east side of Blanco Canyon in Crosby, Dickens, and Floyd Counties. The total extent of this soil is small.

Origin.—Like the Amarillo clay loam, this soil has been formed from the weathering of the heavier deposits of the Tertiary age.

Topography.—The topography of the Amarillo clay is in the main flat to very gently undulating, becoming gently rolling near the edges of the breaks. The large body of this type mentioned is bounded on the east, south, and west by steep escarpments. These constitute the only drainage outlet, there being no streams passing through the type. A very few shallow swales or depressions occur in this soil and serve as catchment basins for the water not absorbed by the soil. These depressions dry up quickly after rains. While the run-off is slow, the underground drainage seems to be fairly good, and little or no damage to crops results from standing water. Good water is obtained in abundance from wells 250 to 300 feet deep.

Utilization.—The Amarillo clay is a good soil, and the greater part of it is under cultivation. The crops grown and the yields obtained average about the same as on the Amarillo clay loam, though in seasons of ample rainfall they are larger on the heavier type. It is probably a better wheat soil than the clay loam, though no fair comparisons were to be had, as wheat has not been grown extensively on this soil until the last year. More cotton and less wheat are grown on this soil than on the Amarillo clay loam, as the areas of clay lie far enough south to enable the cotton to mature.

Lands of the Amarillo clay type sell at about the same price as the Amarillo clay loam.

RICHFIELD SERIES.

The Richfield soils include the darker colored soils of the High Plains. They are associated in occurrence with the Amarillo, occupying areas more nearly level or lying slightly lower. They have the same origin as the Amarillo, the darker color being due to the poorer drainage and consequent greater accumulation of organic matter. The silty clay loam is the only type mapped.

RICHFIELD SILTY CLAY LOAM.

Description.—The surface soil of the Richfield silty clay loam is a dark-gray, dark ashy gray, or dark-brown silty clay loam from 3 to 8 inches deep. The subsoil is a dark-brown or ashy-gray clay, to a depth of about 24 inches, where it passes into a gray or grayish-brown compact calcareous clay. In many places the lower subsoil contains white chalky or calcareous material similar to that in the lower subsoil material of the Amarillo clay loam. When wet the surface soil is very dark or nearly black, but it dries out to a grayish color. The surface bakes rather hard, but if cultivated at the proper time a mellow and friable seed bed results.

In places the layer of surface soil is so thin that the clay soil is turned up by the plow. The type resembles the Amarillo clay loam in some general features, but is readily separated from that type, where typically developed over large areas, by reason of its lack of reddish color and its more nearly level surface. The two types nevertheless are separated with difficulty in some places where they merge gradually into each other. Included in the type as mapped are some small areas of Amarillo clay loam and Randall clay which could not be shown on a map of the scale used.

Location.—The Richfield silty clay loam is mapped in a number of small areas on the High Plains, mainly in Hale, Floyd, and Lubbock Counties. A great many small areas could not be shown on the map. These are scattered over a considerable part of the High Plains in Hale, Floyd, and Crosby Counties. No large areas of the type were found.

Topography.—The surface of this type appears to the eye to be level. This type occupies slight depressions or very shallow basins very little lower than the general surface level, surrounded by gently undulating areas of the Amarillo clay loam. After heavy rains water stands for several days on the surface, but in this region where the rainfall is not heavy the naturally poor drainage of the type is not a serious hindrance to the growing crops.

Origin.—This type has been formed by the weathering of Tertiary material. Owing to a lack of drainage and aeration the material giving it has not been oxidized to the reddish color characteristic of the somewhat better drained Amarillo soils.

Utilization.—The Richfield silty clay loam supports a good growth of grasses, among which buffalo grass predominates. Blue weed is abundant and gives trouble in cultivated fields. Some of the land is cultivated and some remains in pasture. The soil is quite productive and is well suited to the general farm crops commonly grown in this part of the High Plains. Good yields of wheat, oats, kafir, milo, and sorgo are obtained. It is said by farmers that the type is somewhat better suited to wheat and other small grains than to the row crops, though the grain sorghums yield well. In good seasons wheat yields 15 to 30 bushels per acre.

RANDALL SERIES.

RANDALL CLAY.

Description.—The surface soil of the Randall clay is a dark bluish gray to black clay, 12 to 20 inches deep. The subsoil is a gray or light-gray clay containing chalky fragments. Both soil and subsoil are calcareous. The surface soil contains considerable organic matter, but it bakes hard and cracks on drying. When in the proper moisture condition it works into a mellow seed bed.

Location.—The Randall clay is not shown on the map, as it occurs in areas too small. It is developed in the High Plains in lake beds, ranging in area from 20 to 100 acres or more, and is in most cases surrounded by the Amarillo clay loam or Richfield silty clay loam. One or two of these lake beds are found in nearly every square mile covered by the Amarillo clay loam.

Topography.—The areas of this type lie from 5 to 25 feet below the level of the surrounding country. They are flat or basin-shaped, and during seasons of considerable rainfall water may stand on the surface for several months, or until removed by evaporation.

Origin.—These lake beds, or playas, may have existed in the materials as originally laid down, or they may have resulted through a settling or sinking of the underlying rocks, somewhat as sink holes are formed in limestone country. In some cases they may have been formed through removal of material by the wind. The soil material to a depth of several feet has been formed by the washing in of fine particles from the surrounding higher areas. In the western part of the plains the lake beds are surrounded by narrow bands of Brackett clay.

Utilization.—Little of the Randall clay is used for farming, owing to its poor drainage. The surface is usually bare of vegetation, though a heavy growth of blue weed covers the margin of the beds.

The soil is very productive, and good yields of the grain sorghums are obtained in the few marginal areas cultivated.

BRACKETT SERIES.

On the High Plains the underlying calcareous clay or marly material sometimes is exposed at the surface, especially on slopes. It is also found in places as level areas. This gives soils light gray to white in color, with chalky or very calcareous clay subsoils. There are many areas of the Brackett series which are too small to map, and these were included with the Amarillo soils. Two types are mapped, the fine sandy loam and clay.

BRACKETT FINE SANDY LOAM.

Description.—The surface soil of the Brackett fine sandy loam over most of its areas is a grayish-brown or gray loamy fine sand to fine sandy loam, 12 to 30 inches deep, but in the deeper areas the color from about 10 inches downward may be grayish yellow. The subsoil is a white, chalky, friable clay, though quite compact when dry. The immediate surface of areas of this type is white and compact when dry. In places the areas consist of bare eroded hills or ridges 10 to 20 feet high. Here the material consists of 36 inches or more of a chalky, clayey fine sand, slightly sticky when wet and very compact and hard when dry. There are included small bodies of Brackett clay and Amarillo soils.

Location.—The Brackett fine sandy loam is of small extent. It is confined to the western High Plains, in the vicinity of Muleshoe in Bailey County and around Twin Lakes in Lynn County.

Topography.—The surface of this type is gently undulating to nearly level, but some ridgelike areas are included. The soil in these is not typical. Drainage is fairly good, except in a few basinlike areas, which hold water a short time after rains.

Origin.—This type has been formed by the exposure and weathering of the marly or calcareous formations which underlie the Amarillo soils at depths of a few inches to 2 or 3 feet or deeper. The calcareous material is found at or near the surface. The sandy surface is due to the accumulation of material blown from the sand-hill areas not far away.

Utilization.—The Brackett fine sandy loam is utilized principally for grazing, though only a moderate quantity of wild grass grows on it. Among the grasses growing extensively on this type are blue grama, tall grama (*Bouteloua curtipendula* Michx.), poverty grass (*Aristida subundiflora* Nash), bluestem, and others. Small areas of the type are cultivated, and where moisture conditions are good

fair yields are obtained on some of the better areas; that is, where there is not too much calcareous material.

BRACKETT CLAY.

Description.—The surface soil of the Brackett clay is a light-gray or gray to almost white, friable chalky clay about 6 inches deep. The subsoil to 36 inches and deeper is a white, chalky clay containing more calcareous material than the surface soil. In the more elevated positions the surface soil appears quite light in texture when dry, though very sticky when moist. In places hardened chalk or marl fragments occur throughout soil and subsoil.

Location.—The Brackett clay occurs in small areas, generally too small to show on a reconnaissance map. It is mapped along the playa lakes in the western part of the area on the High Plains, mainly in Cochran, Hockley, Bailey, and Lamb Counties. Areas of the type vary in size from a few acres to several hundred acres, only the larger of which are shown. The type also occurs as narrow strips along the slopes of some of the shallow valleys in the High Plains.

Topography.—The topography of the Brackett clay is undulating to rolling, and the surface drainage is good.

Origin.—The Brackett clay represents areas of caliche that have been exposed through the erosion of the surface soils by water or wind.

Vegetation.—In many places the areas of this type are almost bare of vegetation, and nowhere is the vegetation heavy. In places there are a few small mesquite trees, some yucca (bear grass), wormwood (sagebrush), and tallow weed. Only a scanty growth of grass occurs. Some fine-top salt grass (*Sporobolus airoides* Torr) grows in places, and there is also a small scattered growth of grama grass and buffalo grass.

Utilization.—The Brackett clay is of little value for cultivated crops and is used only as grazing land.

MILES SERIES.

In the central part of the area, just east of the High Plains escarpment, there are some good-sized areas of sandy soils lying on high areas and ridges in the eroded plains. These soils are grayish brown or brown to reddish brown in the surface layer and red in the upper part and reddish yellow or brown in the lower part of the subsoil. The latter is calcareous, some of the material resembling the caliche of the High Plains. In places waterworn gravel and conglomerate underlie these soils. These types are included in the Miles series, of which two types, the sandy loam and the fine sandy loam, are mapped.

MILES SANDY LOAM.

Description.—The surface soil of the Miles sandy loam is a brown, light-brown to reddish-brown sand or loamy sand, varying in extreme cases from 3 to 20 inches in depth, but ordinarily from 6 to 10 inches. The subsoil is a red, brownish-red, or reddish-brown friable, rather heavy clay, which may extend to a depth of 36 inches in the smoother areas, but which in many places passes at 20 to 30 inches into yellowish-red or yellow calcareous clay. Where the surface soil is deep the immediate surface is very loose and incoherent and dries out to a grayish brown color; in the shallow areas (4 inches or less) the color is reddish, and the soil compacts on drying. On some slopes and knolls included areas consist largely of white chalky clay or marl. In places, especially on steep slopes or in cuts, beds of small waterworn quartz and quartzite gravel are exposed at the surface or appear several feet below it, and small spots of this material may outcrop on the higher knolls. In places the gravel is cemented into a hard "concrete" or conglomerate. Beds of such material several feet thick are seen in cuts or outcropping on steep slopes.

Location.—The Miles sandy loam forms considerable areas in the northern part of Dickens County and the southern part of Motley County.

Topography.—These areas occur in high, gently rolling to rolling country for the most part as ridges extending from near the breaks of the High Plains eastward onto the Permian formation, which they bury to varying depths. Little of the type is so hilly or rolling as to prevent cultivation. The soil absorbs moisture rapidly, and there is not much run-off, even on steep slopes. There are a few small depressions, but these do not hold water long enough to prevent cultivation. In large areas of the type the surface is somewhat bumpy or is marked with hillocks of wind-blown material. It is said that the water obtained from wells on this type is free from gypsum.

Origin.—The Miles sandy loam is derived from reworked water-laid material, but doubtless a large part of the sandy surface material has been accumulated by wind action.

Utilization.—Originally all of this type was in large ranches and was utilized for grazing, but within the last few years much of it has been placed in cultivation, and at present probably 10 or 15 per cent of the total area is farmed. There are a number of good farms on the type in northern Dickens County and in southern Motley County.

The native vegetation consists of grasses. Sedge grass is rather abundant, and there is some grama and a small growth of poverty and buffalo grass in places. A scrubby oak, locally called shin oak, is abundant. Wormwood, locally called sagebrush, and many weeds grow profusely. Some bear grass (yucca) and an occasional small

mesquite tree grow on heavy-textured spots. The uncultivated land is all utilized for grazing.

The principal crops grown are sorgo, the grain sorghums, corn, and cotton. Of the grain sorghums, milo is grown most extensively, followed in order by kafir and feterita. The soil is not suited to the production of small grains, though wheat and oats could be grown on the heavier areas for pasturage. Sorgo produces good yields of fodder or hay. Some sorghum sirup is made on the farms. Good crops are produced in favorable seasons, and even in dry seasons the soil holds moisture well and will produce fair yields. Crops on this soil are said to continue growing longer in dry seasons than crops on the heavier soils.

The grain sorghums are quite certain to produce good yields, milo yielding 20 to 40 bushels per acre in good seasons. Kafir and feterita give about the same returns. With sufficient rainfall corn yields 20 to 30 bushels, and cotton averages one-half bale per acre.

This type is texturally well adapted to truck crops and to some fruits. Small orchards and gardens are found on most of the farms. These produce well in favorable seasons. Plums and grapes do especially well.

While this soil produces well with a minimum of rainfall, it must be handled skillfully to get a stand of spring-planted crops because of the tendency to drift. The winds either cover the young plants or blow the soil from around them, making it necessary sometimes to plant the land more than once. Running the rows east and west, at right angles to the prevailing winds, is said to prevent drifting to some extent, especially when the land is listed. The winds in May are not so strong as in the earlier months, and late-planted crops are frequently more successful than those planted early.

The soil of this type is deficient in organic matter, and with continued clean cropping this deficiency becomes greater every year. The use of well-rotted manure and the plowing under of all vegetable matter would be beneficial. In this region the organic constituents of the soil are more than ordinarily valuable, because they greatly increase its power to hold moisture. They also counteract to some extent the tendency of the soil to drift.

It seems possible to keep the soil in a fairly productive condition by maintaining a good supply of organic matter in it and by growing leguminous crops, such as cowpeas. The soil is believed to be well suited to the production of peanuts. Sudan grass would give good yields on it. Excellent melons and muskmelons are grown.

This land, unimproved, sells for \$15 to \$30 an acre, and improved for \$30 to \$50 an acre.

MILES FINE SANDY LOAM.

Description.—The surface soil of the Miles fine sandy loam is a reddish, reddish-brown, or brown loamy fine sand 6 to 15 inches deep. The upper subsoil is a dull-red, brownish-red, or reddish-brown sandy clay. At 20 to 30 inches this layer passes into yellowish-red or yellowish-brown friable calcareous clay, which continues to a depth of 3 feet or more. A stratum of chalky material may appear in the lower subsoil, and in places on slopes or knolls it lies near the surface. On the more even surfaces there may be little change in the subsoil to 36 inches. In some places on knolls and slopes rounded quartz and quartzite gravel are scattered over the surface, and cuts sometimes show beds of this gravel several feet below the surface. In places beds of conglomerate or concrete several feet thick occur.

The surface soil where cultivated is friable to somewhat loose and incoherent, though over a great part of the type the surface in pastures is hard.

Location.—The Miles fine sandy loam occurs in a number of areas in the central part of the survey, just east of the High Plains escarpment and eastward in the rolling prairies. Large areas of the type lie in Garza, Dickens, Motley, and adjoining counties.

Topography.—The topography is gently rolling to rolling and hilly, but a very large proportion of the type is cultivable. Some eroded and hilly areas are indicated on the map by hachures. The soil and subsoil absorb water readily, and the subsoil holds water well in dry seasons. Drainage from the surface is good, and only on rather steep slopes is erosion serious.

Origin.—The Miles fine sandy loam corresponds in origin with the Miles sandy loam. In the eastern extensions of the type the material thins out and in places merges into the Permian Red Beds soils. Where the latter are sandy, it is rather difficult to separate the Miles from the Vernon, as they are in these places quite similar in texture and color. In a map of the scale used in the present survey it is possible to show these types only in a general way.

Utilization.—The native vegetation is practically the same as that on the Miles sandy loam. In many places there is a scattering growth of small mesquite trees, especially where the surface soil is comparatively heavy. Shin oak is a characteristic tree on the lighter-textured areas. Chaparral and catclaw bushes grow in places. There are a number of coarse weeds, some wormwood, and bear grass. Coarse native grasses, chief among which is sedge grass, flourish generally. Buffalo grass and mesquite grass grow mostly in spots of heavy soil, and there is some poverty and grama grass. Originally this soil was all in large ranches, and the greater part

of it is still used for grazing. Probably 30 per cent of the type is now farmed.

The same crops are grown, the same methods used, and about the same yields obtained as on the Miles sandy loam. It is probable that the fine sandy loam is slightly more productive on the smooth areas where the surface soil is relatively heavy. The price of land is about the same as for the sandy loam.

DERBY SERIES.

In the eroded plains in the eastern part of the area there are bodies of loose fine sand, some of which is blown into a dunelike surface. The mass of the material is pale yellow with a few inches of grayish or grayish-brown color on the surface. The more loamy material in this area has a darker color, being brown or reddish brown. The sandy material, or much of it, seems to have blown from the dry beds of the streams. These areas have been mapped in the Derby series. The fine sand, with a dune phase, and the loamy fine sand occur in the present survey.

DERBY FINE SAND.

Description.—The Derby fine sand consists of grayish-brown or light-brown fine sand which passes at a shallow depth into pale-yellow or brownish-yellow loose fine sand extending to a depth of several feet. The soil contains very little organic matter, though in some places the first inch or two is slightly loamy and of a brownish color, owing to small accumulation. Small areas have a reddish color, and in several places the type merges gradually into soils of the Miles and Vernon series.

Location.—The Derby fine sand is found only on the rolling prairies of the eroded plains. Areas of considerable extent occur in Motley, Cottle, Dickens, Kent, and Stonewall Counties. A few areas are too small to be shown on the map. Much of the type lies near the larger streams.

Origin.—The Derby fine sand is derived mainly from wind-blown material, drifted from beds deposited by the streams. It is possible that a part of the material may have been laid down in its present position by water.

Topography.—The surface of the Derby fine sand is undulating to rolling and in places is marked by small hills or dunes. The areas are well drained throughout, both the run-off and the under-drainage being free. The soil is loose and porous and absorbs rain water rapidly. Some of the main areas are ridgelike, occupying the higher positions in the region of their occurrence.

Vegetation.—The greater part of the Derby fine sand is covered with a thick growth consisting chiefly of stunted shin oak, bear grass, and a wormwood, called sagebrush. In some of the more nearly level areas, mesquite, grama, and some coarser grasses, such as sedge grass, grow to a considerable extent. Mesquite trees and cacti may also occur in the low places where the soil is somewhat compact. The tops of some dunes that are still shifting are entirely devoid of vegetation.

Utilization.—This type is not especially productive, and as long as there are areas of better soil uncultivated it is not likely to be used for growing crops. The soil is of such loose structure and fine texture that it is easily drifted, which is one great drawback to its cultivation. A few small tracts are farmed, but these are usually marginal areas in which the subsoil is closer to the surface than typical and in which the surface is often slightly loamy. These places are cultivated with some success, though drifting is often excessive in the spring, and replanting of crops is often necessary. This trouble is sometimes partly avoided by planting late in the spring after the period of highest winds has passed. This soil absorbs practically all the rainfall, and it retains moisture much better than do the heavier soils. As a result, crops when once started do fairly well during seasons of average rainfall. The more nearly level areas, where grass flourishes, are valuable for grazing, and this is the most important use to which the land is put. Grasses on this soil begin to grow early in the spring.

Where cultivated, the land is utilized for the production of milo, sorgo, cotton, and melons. In good seasons milo yields from 10 to 30 bushels; corn, 8 to 20 bushels; and cotton one-fourth bale per acre.

Land of this type sells in large bodies for \$5 to \$10 an acre.

Derby fine sand, dune phase.—The Derby fine sand, dune phase, consists of 3 feet or more of fine sand, the first few inches when dry being grayish to light brown and the remainder of the profile pale yellow.

Location.—This soil occurs in long areas extending from the New Mexico line to the eastern part of Hale County, and in some other areas in Cochran, Yoakum, and Terry Counties.

Origin.—The Derby fine sand, dune phase, has been formed from accumulations of sand drifted from the Tertiary or Quaternary deposits.

Topography.—The dunes occur scattered thickly over the Amarillo fine sandy loam, and in places form approximately half the total area. They are 10 to 30 feet high and some are still in motion, supporting no vegetation, or at most only a few small hackberry trees.

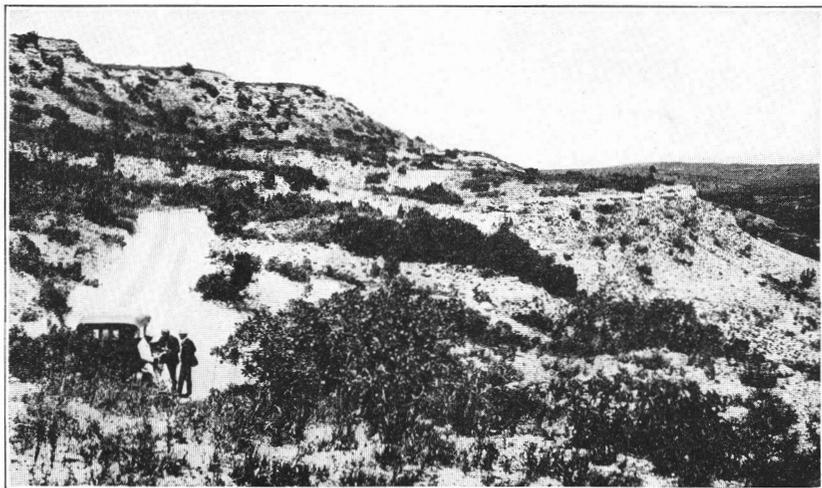


FIG. 1.—ROUGH BROKEN LAND FORMING ESCARPMENT OF THE HIGH PLAINS.

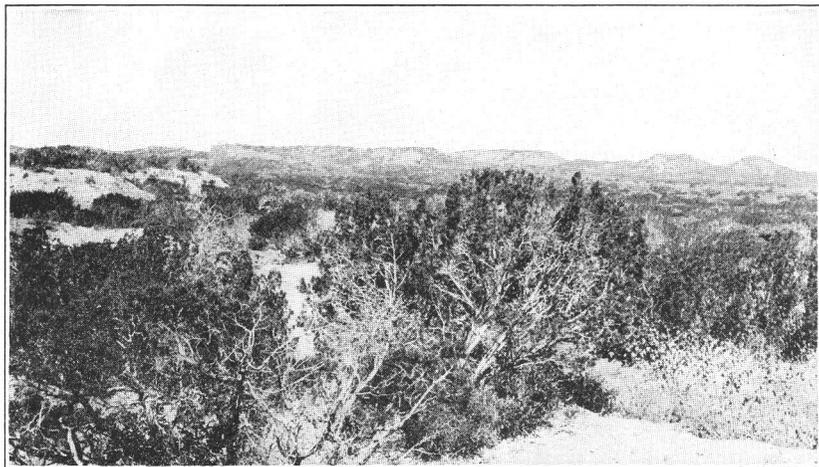
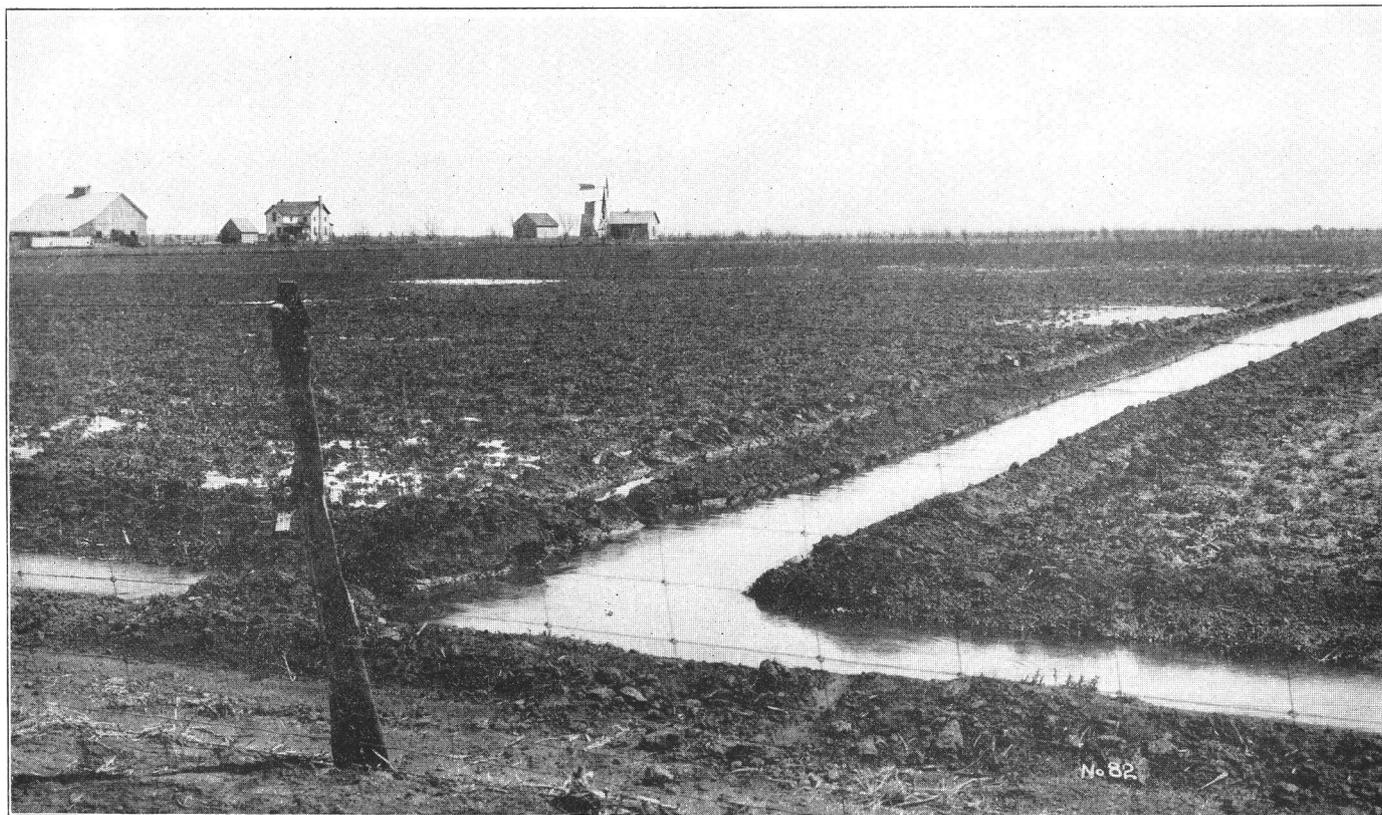


FIG. 2.—ROUGH BROKEN LAND NEAR STREAMS IN THE ERODED OR LOW PLAINS.



METHOD OF IRRIGATING LAND IN THE HIGH PLAINS.

The soil is the Amarillo clay loam. Note pump house and windmill used to supply the water.



IRRIGATED FIELD OF CLOVER AND TIMOTHY NEAR PLAINVIEW.
Little timothy and clover is grown in the region. Evidently the crop does well under irrigation.



IRRIGATED FIELD OF SUGAR BEETS ON THE HIGH PLAINS, NEAR PLAINVIEW.

Others are covered with weeds, coarse grasses, and shrubs of various kinds. Shin oak, yucca, or bear grass, and a wormwood, locally called sagebrush, are abundant. The grasses most abundant seem to be the little bluestem (*Andropogon scoparius*), some grama grass, and sedge grass. The skunk bush (*Schmalz trilobata* Nutt), golden aster (*Chrysopsis stenophylla*), and poverty or needle grass are also found.

Utilization.—The Derby fine sand, dune phase, is utilized altogether for grazing. The larger dunes afford shelter for cattle in cold weather, and the grass, though not so abundant or so nutritious as on the heavier Amarillo soils, is said to start growth earlier in the spring and to furnish better grazing during dry seasons than on the heavy soils.

It seems probable that the level or basin areas between the sand hills, which comprise 25 to 50 per cent of the total area, and which are frequently composed of the Amarillo fine sandy loam, light phase, could be utilized for growing forage to some extent. Sorgo and the grain sorghums could doubtless be grown in these places, and perhaps sweet clover could be grown here to good advantage.

The fact that the land is not generally adapted to farming depresses its price. It is, however, considered a rather valuable land for grazing and sells in large areas for \$5 to \$10 an acre.

DERBY LOAMY FINE SAND.

Description.—The Derby loamy fine sand consists of about 10 inches of a brown, grayish-brown, or slightly reddish brown, loose, loamy fine sand underlain by brown, reddish-brown or brownish-red, friable, loamy fine sand to light fine sandy loam. Typically the soil in cultivated fields has a slight reddish cast; in virgin areas the upper few inches is grayish brown. The depth of the loose sandy materials ranges from about 3 to many feet. In the eastern parts of Hardeman and Foard Counties this soil is distinctly fine in texture, but for some miles in the northern part of Hardeman County the type as mapped approaches a medium loamy sand in texture.

Location.—This type is mapped in one large area along the Red River in Hardeman County and in two smaller bodies lying east of Chillicothe and Margaret, respectively.

Topography.—The surface features vary from rather smooth slopes and basins to undulating or slightly rolling and dunelike hills. The surface is free from gullies and in general is favorable for cultivation.

Origin.—This soil has been formed by wind action, which may have reworked original sandy deposits of Permian material and which certainly has accumulated materials from the beds and terraces of the Red and Pease Rivers.

Vegetation.—The vegetation on the Derby loamy fine sand consists of wormwood, some shin oak, mesquite, and hackberry trees, yucca, and some mesquite, buffalo, and grama grasses. There is also a varied growth of flowering weeds belonging largely to the Compositæ family.

Utilization.—Probably because of its peculiar loamy structure, this type is valued more highly for farming than the other very sandy soils of this section. It is estimated that more than 70 per cent of the type is under cultivation, and the remainder is used chiefly as pasture for the farm work stock. The crops grown are cotton, milo, kafir, feterita, sorgo, corn, cowpeas, wheat, melons, and all kinds of garden vegetables. Cotton is the chief cash crop, as wheat is not nearly so well suited to this soil as to heavier types. A yield of cotton is fairly sure, even in dry years when the crop fails on heavier soils. The average yield is approximately one-third bale per acre. Milo and the other grain sorghums average a little less than 30 bushels per acre, and produce some grain, even in the driest seasons. This is probably the best corn land in this section of the State. The average yield on some farms is more than 20 bushels per acre. If better markets were available, this land would become important in the production of melons and other truck crops. Considerable fruit, consisting of peaches, plums, grapes, and cherries, is produced in small home orchards.

Because of its loamy nature this soil is not so subject to movement by the wind as the other sandy soils, but under the best practice steps are taken to prevent drifting as far as practicable. This is done by leaving all the vegetation possible on the ground when crops are harvested, by leaving the surface rough when broken, and by cultivating after rains, especially where the water may have washed out some loose sand over lower ground.

Farms of this type sell for \$30 to \$70 an acre.

ALLUVIAL SOILS.

The extent of alluvial soils in the area is relatively small. With one exception they are of recent origin. They occur in comparatively narrow bottoms. On the High Plains these areas are valuable agricultural soils, but owing to their small extent it is not practicable to show the types separately or even to make series distinctions. In the Permian Red Beds the brown to reddish alluvial soils are mapped in two general groups as Miller sandy soils and Miller heavy soils and the brown or grayish soils in the Bastrop series. The soils on some small stream terraces in the Permian region, though not typical, also have been mapped as Bastrop.

ALLUVIAL SOILS, UNDIFFERENTIATED.

Description.—The alluvial soils, undifferentiated, have a dark-colored surface soil ranging, in general, from fine sandy loam to clay in texture, with some small areas of fine sand. The subsoils are heavy in texture and usually dark brown to nearly black in color, the fine sand areas being grayish. In most places there is really little physical change from the surface downward through the 3-foot section. Both the soil and subsoil are calcareous.

Location.—These soils occur mainly along the small draws or streams of intermittent flow in the High Plains, but are mapped also along Duck and Dockum Creeks, in Dickens County, in the low plains. The areas represent bottom lands and are narrow, only a few hundred feet to one-fourth mile wide.

Origin.—These soils are derived from materials washed mainly from areas of the Amarillo soils and deposited by overflow waters.

Topography.—The surface is flat and lies from 4 to 6 or 8 feet above the stream beds. The surrounding uplands are 20 to 50 feet above the bottoms. Drainage is good. It is said that this land is no longer subject to overflow.

Utilization.—The alluvial soils, undifferentiated, are very productive and are much in demand. In the sections of the High Plains where farming has developed, or near railroads, land of this sort is cultivated extensively. It is especially adapted to alfalfa, which in years of normal rainfall gives four cuttings of about 1 ton each. Near Plainview some fields under irrigation give even higher yields. It is said that the alfalfa seed grown on this soil is especially good. The land produces 40 to 60 bushels of corn per acre in good seasons and large yields of the grain sorghums and of sorgo. It is, however, used mostly for alfalfa. On the areas in Dickens County the principal crops are the grain sorghums and cotton, of which good yields are obtained. Some wheat also is grown on these soils as developed in this part of the survey.

Land of this kind located near railroads sells for \$100 or more an acre.

BASTROP SERIES.

BASTROP FINE SANDY LOAM.

Description.—The surface soil of the Bastrop fine sandy loam is a brown to reddish-brown fine sandy loam. This is underlain by a brown or reddish-brown loam, which passes at about 18 to 20 inches into a reddish-brown to red fine sandy clay, and usually grades at 24 to 30 inches into a yellowish-red or reddish-yellow friable fine sandy clay.

Location.—The Bastrop fine sandy loam is of small extent. It is an old alluvial soil and occurs as narrow strips on second bottoms or benches several feet above and bordering some of the larger stream bottoms of the area. The largest areas lie on the Salt Fork of Brazos River in Knox County, and the North Fork of the Wichita River in King and Cottle Counties. Some areas of the type occur in Motley County. A narrow terrace along Quitaque Creek in the northern part of this county is included but is not typical Bastrop, the soil being a brown fine sandy loam and the subsoil a reddish-brown loam to sandy clay loam or sandy clay, resting on a marly bed.

Origin.—The Bastrop fine sandy loam has been formed through deposition by streams of material washed from the uplands of both the High Plains and the eroded-plains sections. As erosion is most active in the eroded-plains country, it is probable that the latter has supplied the greater part of these deposits. There is also some colluvial wash from the adjacent uplands along the edges of the type.

The soil of this type represents old flood plains of the streams along which they lie. They now stand several feet above the high-water mark of these streams.

Topography.—The surface of the Bastrop fine sandy loam is nearly level or slopes gently streamward. The run-off is not rapid, but the open structure of soil and subsoil insures good underdrainage, and the land is on the whole well drained.

Utilization.—The Bastrop fine sandy loam is utilized principally for general farming, and probably 75 per cent is cultivated. It is one of the most productive soils of the area. The humus content is fairly high, and the soil is retentive of moisture. The areas receive the surface drainage from the higher upland areas, which increases the supply of moisture. Cotton, corn, and milo are the principal crops. In favorable seasons cotton yields one-half to 1 bale per acre, corn 15 to 40 bushels, and milo 30 to 50 bushels. Sorgo also does well, yielding from 4 to 10 tons of dry forage per acre. Wheat yields 10 to 25 bushels per acre, with an average of 15 bushels. Field beans, peas, and peanuts give good yields. Sweet potatoes, garden vegetables, and a number of fruits do well.

The areas of the Bastrop fine sandy loam are small and included in farms with other types of soils. The land ordinarily brings about the same price as the associated soils.

MILLER SERIES.

MILLER SANDY SOILS.

Description.—The Miller sandy soils comprise Indian-red to chocolate-brown fine sandy loam and loamy sand underlain by an Indian-

red fine sandy loam subsoil. The depth of the surface soil ranges over most of the type from about 10 to 20 inches, but in places there is little change in the physical characteristics of the soil material within the 3-foot section. On account of the small extent of the individual areas of the types included in this group, they could not be separated on the map.

Location and topography.—The Miller sandy soils occur as very narrow bottoms along the larger streams in the eastern part of the area. The surface is level. The areas are subject to overflow, but at other times the drainage is good. The surface of the bottoms lies 5 to 15 feet above the stream bed.

Origin.—These alluvial soils have been formed from materials washed mainly from areas of the Vernon and Foard soils. Doubtless some of the material has been brought from areas of the Miles and Amarillo soils lying farther west in the High Plains region.

Utilization.—The areas of Miller sandy soils are small, and no farms are composed wholly of them. The virgin land supports a good growth of grass and is utilized principally for grazing. Some small bodies used for farming give excellent crops in good seasons, the soils, where less sandy, being quite productive. Milo and other grain sorghums, sorgo, corn, and cotton all do well.

MILLER HEAVY SOILS.

Description.—The Miller heavy soils consist of silty clay and silty clay loam of dark-brown or chocolate-brown color, underlain at 10 to 15 inches by Indian-red or brownish-red silty clay. The types occur in such small areas that they could not be mapped separately. A very small area of Bastrop clay loam was included in mapping these soils. This is about the same as the Miller clay loam in color and texture, but occupies a terrace lying above overflow.

Location.—The Miller heavy soils occur in a few small areas along some of the streams in the northeastern part of the area, in the region underlain by the Permian Red Beds formation.

Topography and drainage.—The surface of these soils is nearly level. Overflows sometimes occur, but are infrequent. On the whole the areas are fairly well drained.

Origin.—These soils are derived from alluvial material washed from near-by areas of the heavier Vernon and Foard soils.

Utilization.—Only a small area of the Miller heavy soils occurs in the survey. A considerable proportion of their extent is cultivated, especially where they border tillable upland soils. They are very strong productive soils, and all the crops of the region are grown successfully. Considerable alfalfa is grown and yields well. The grain sorghums, sorgo, corn, cotton, and wheat are the main crops.

MISCELLANEOUS MATERIALS.

ROUGH BROKEN LAND.

Throughout the central and eastern parts of the area there are considerable bodies of land that are too rough, broken, eroded, and hilly for cultivation. These areas include a variety of soils, ranging in texture from sand to clay, stony in places and gravelly in others, with colors ranging from white or gray to red and brown.

Rough broken land is of three general kinds—stony escarpments along the edge of the High Plains, eroded areas along the foot of the escarpment, and broken slopes and hills along stream courses.

The Rough broken land owes its origin entirely to erosion, many small streams rising in this rough country.

In many places a scattering growth of small cedar trees (juniper) is found on this land, and also some small mesquite trees. Shrubs, brush, and a thin stand of coarse grasses grow in the least eroded spots, but in many places the surface is bare of vegetation.

The Rough broken land is utilized principally for stock raising by ranchers who own considerable bodies of this land and adjacent smoother lands. It is considered valuable for ranching, as the rough areas provide good protection for stock in winter, and the valleys and smoother areas furnish surprisingly good pasturage. The land will doubtless always be used for ranching.

When sold in large bodies the Rough broken land sells for \$5 to \$10 an acre, or more in places. It includes some areas of relatively smooth land, and the price varies with the proportion of this more desirable land in the different parts.

The illustrations (Pl. XI, figs. 1 and 2) show topographic forms of Rough broken land in the High Plains and in the eroded plains.

ROUGH STONY LAND.

The term Rough stony land is used to indicate rough areas where, over a considerable proportion of the land, stony material outcrops or is strewn in large and small fragments over the surface. The soil material between the rocks is red clay or clay loam of the Vernon series. The stony material is composed of limestone or gypsum rock.

This land occurs in several small bodies in Cottle and Foard Counties in the Permian Red Beds area.

The topography is hilly to rough and broken, even the smoother areas being gullied and washed in most places.

The principal vegetation is a scattering growth of dwarf mesquite trees, weeds, and short native grasses. The grass is very thin or absent over considerable parts of the surface. Cedar grows in some places.

The land is utilized for grazing, but is not valued highly, as the growth of grass is scant. It is of some value in affording winter protection to stock.

IRRIGATION.

Irrigation is being considered in a general way by many people throughout the Northwest Texas area. In a region of irregular rainfall, where there are seasons when the precipitation is so far below normal as to injure crops, and where droughty conditions may continue throughout several months or longer, it is important to consider any method by which water may be brought to the soil artificially. This is of especial interest when it is considered that the soils of the area are suited to so many crops and are so productive when moisture is available.

There are two ways of supplying water for irrigation in the region: (1) impounding storm or rain water in reservoirs, and (2) pumping from wells.

Reservoirs have not been used on the High Plains, as there are few ravines or stream beds to dam. Again, the surface of the High Plains is so smooth that there is little run-off, although the depressions and swales catch some water. It seems that irrigation on the High Plains from impounded water is not feasible on an extensive scale, though further consideration and study may prove the contrary.

Although it has been found feasible to irrigate considerable areas of land on the High Plains in certain sections by pumping water from wells, this is not possible throughout the region, but only in certain so-called shallow-water districts. Small patches of land in gardens and orchards are watered in all parts of the section by water pumped from wells by windmills, and while this is not practicable on any considerable acreage, it is very profitable as an insurance of the home supply of vegetables and fruit.

On the rolling prairies in the eroded-plains section of the area much of the underground water contains gypsum and other salts. While this water is more or less unpalatable, it is drunk readily by stock and is by no means always unfit for human use. However, it is possible that the salts in this water, though small in amount, may make it unsuitable for irrigation, owing to accumulation of salts in the soil until the concentration shall become sufficient to injure crops. This is mentioned as a possibility, no conclusive data based on experiment and analysis being as yet available on this point.

In the eroded or low plains it seems that impounding rain water in large or small reservoirs may prove the more successful method of providing satisfactory irrigation water. The surface of this region

is rolling to nearly level in places, and there are many large stream channels and lesser drainage ways, dry most of the time, that could be dammed to catch surface water. One important project of this character is in operation, and there is considerable additional land that could be irrigated from such reservoirs. The area now irrigated lies near Quanah in Hardeman County.

The Quanah project has been in operation about eight years. The water is impounded in a small stream valley. The dam is 6,000 feet long and 49 feet high where it crosses the stream channel. The dam and other irrigation work cost \$60,000. The drainage basin has an extent of about 30,000 acres. The lake formed covers 1,000 acres and ordinarily holds about 8,000 acre-feet of water. This is considered sufficient to irrigate 1,500 to 2,000 acres. An area of 800 acres was irrigated in 1918. It is said that no trouble is experienced from an excess of salts in the water, though when the lake gets low the water contains an appreciable quantity of gypsum.

Water from the lake is carried by gravity to the land under irrigation. The soil is the Foard clay. The principal crops are alfalfa, wheat, the grain sorghums, sorgo, and cotton. It is reported that the average yields of crops under irrigation, for the period during which the Quanah project has been in operation, have been twice the average obtained on dry-farmed lands.

Alfalfa is irrigated after each cutting, but usually not before the first cutting in the spring. Wheat is watered early in April and when necessary about three weeks later. The grain sorghums are given one to three irrigations, the number depending on the season. Cotton is irrigated when the first blooms appear and again three weeks later. In some years irrigation is not needed, and in some only a little is necessary.

Within the last few years the practice of irrigation has been taken up by a considerable number of farmers in certain shallow-water districts in the High Plains. These districts are those in which water rises in the wells to within 25 to 75 feet of the surface. The wells are usually 200 or 300 feet deep. Several water-bearing strata or levels are encountered in boring to this depth, so that a good supply is obtained. The largest of these districts extends west from Plainview to Portales, N. Mex., northwest into Deaf Smith County, east to the edge of the High Plains, and south to below Lubbock. There are areas within this district where the water does not rise to within 75 feet of the surface, but this outlines the area in which as a general rule it does. The depth at which water stands in the wells of this district varies from 12 or 15 feet at Portales, N. Mex., and 16 to 30 feet near Muleshoe in Bailey County, to about 50 feet around Plainview. A number of farms have been under irrigation

around Plainview for several years, while a few are irrigated around Muleshoe and some around Slaton. The results thus far have shown that the land responds well under irrigation. The principal irrigated crops are wheat, kafir, milo, and alfalfa. Apparently alfalfa is the most profitable crop grown here under irrigation. While it has been fully demonstrated that irrigation is feasible and even profitable, not all those who have undertaken irrigation farming have been successful. This is attributed to several causes. The main cause seems to have been the inexperience of farmers. Many are unfamiliar with the proper methods of applying water and do not understand the care and operation of pumping machinery. Failure has resulted also from neglect to put water on the land when needed. It is generally admitted that many try to irrigate too much land with the equipment at their command. The cost in recent years has been increased by higher cost of machinery, fuel, and labor.

In the High Plains 2 or 3 acre-inches of water are applied at each irrigation. Where the land is flooded, as with alfalfa or wheat, about 7 to 10 acres a day can be covered. Twelve to 14 acres of row crops such as kafir and milo can be watered in a day. The cost of each irrigation is about \$1.50 per acre. A crop is irrigated two or three times. Some practice flooding the land in the winter for crops to be planted in the spring.

It is estimated that at present (1919) the pumping plant for a 160-acre farm costs \$5,000 to \$8,000. The pumps lift 1,200 to 2,000 gallons per minute, and while the water level in the well falls under this draft it is never permanently lowered. No reservoirs are used, the water being pumped directly into the main ditches. The lower subsoil or substratum of marly clay is quite porous, and it is estimated that a large percentage of the water is lost through downward percolation. No alkali or other salts are left in the land by this well water.

It seems probable, after the methods of irrigation have been standardized and proved, that irrigation will be universally successful in the shallow-water districts, or where water rises to within 50 or 60 feet of the surface.

The principal soil irrigated on the High Plains is the Amarillo clay loam. (Pls. XII, XIII, and XIV.) In some years no irrigation is needed, and in many others only a small quantity is required to tide crops through short periods of drought.

The United States Department of Agriculture is carrying on irrigation experiments near Plainview in order to determine the proper methods to be used in the High Plains region.

SUMMARY.

The Northwest Texas reconnoissance covers 22 counties in the northwestern part of the State. The area consists in the western part of high, nearly level plains, and in the eastern part of lower, rolling plains, between which major divisions there is a belt of rough, broken country forming an escarpment. The highest altitude is about 3,500 feet, and the lowest somewhat less than 1,500 feet above sea level.

The region, though still sparsely settled in many parts, has developed rapidly in the last few years, especially near railroads.

The climate is healthful. It is semiarid. The annual precipitation, which averages a little over 20 inches yearly, varies greatly from year to year. Crops often suffer from drought, though the rainfall may be sufficient to give good yields for several years in succession. Complete crop failures are rare. The greater part of the rainfall generally occurs in the late spring, summer, and early fall months.

The soils are derived from the Permian formations and from Tertiary and Quaternary deposits. Small areas of recent-alluvial and wind-blown soils are found. Most of the soils on the High Plains belong to the Amarillo series and on the low plains to the Vernon and Foard series.

The soils are for the most part quite productive, rainfall being the limiting factor in this general region. The heavier soils, such as the loams, clay loams, and clays, are best suited to the small grains. Forage crops do well on all the soils, but yield better in dry seasons on the sandy soils with clay subsoils. Cotton and corn also give better results on the sandy loams in dry seasons. When rainfall is sufficient, higher yields are obtained on the heavy soils. The sandy loams absorb the rainfall more completely than the heavy soils, and hold it better than the heavy soils, but are more likely to be damaged by winds.

Much of the land formerly used for ranching is now largely used for farming, though some of the large ranches still remain intact. Stock farming is practiced extensively. It is the most dependable type of agriculture for the region. The general farm crops can be grown successfully in conjunction with the raising of cattle, sheep, or hogs.

The principal crops are milo, kafir, wheat, cotton, and sorgo. Alfalfa, millet, feterita, Sudan grass, and other miscellaneous crops are grown less extensively. The grain sorghums, milo, kafir, and feterita are the most certain crops of the region and are valued highly for stock feed. Small quantities of vegetables and fruits are raised for home use.

The rougher and less desirable lands, suitable for grazing, are held at \$5 to \$20 an acre. In general, good tillable land sells for \$25 to \$50 an acre, and near towns for \$75 or more.

Some land in the High Plains is irrigated with water pumped from wells, and in the lower-plains section there is an irrigation project drawing its supply from a reservoir.



[PUBLIC RESOLUTION—No. 9.]

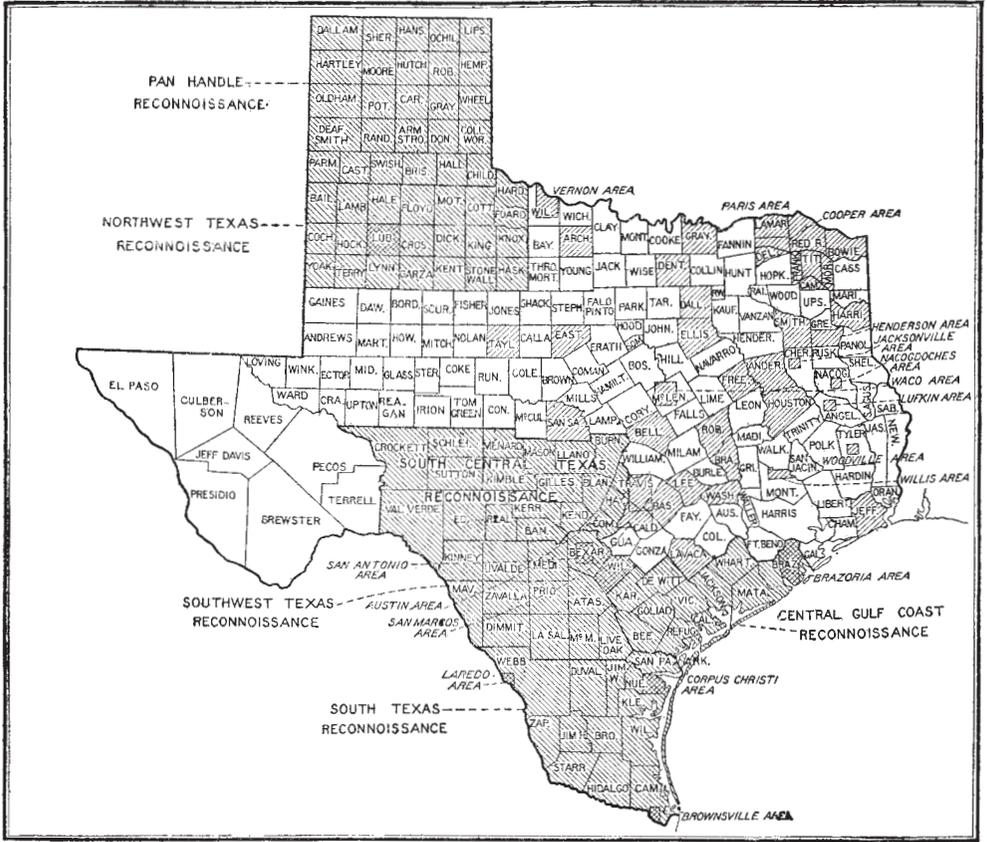
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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.]



Areas surveyed in Texas, shown by shading.

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