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Soil Survey of Potter County, Texas

By

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and

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United States Department of Agriculture

Bureau of Chemistry and Soils

In cooperation with the Texas Agricultural Experiment Station

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By E. H. TEMPLIN, Texas Agricultural Experiment Station, in Charge, and A. E. SHEARIN, United States Department of Agriculture

COUNTY SURVEYED

Potter County is in the northwestern part of Texas (fig. 1), in approximately 35°30′ N. latitude and 102° W. longitude. It is one of the counties forming the Texas Panhandle. The northwestern corner is 80 miles southeast of the northwestern corner of the State. The county embraces an area of 920 square miles, or 588,800 acres.

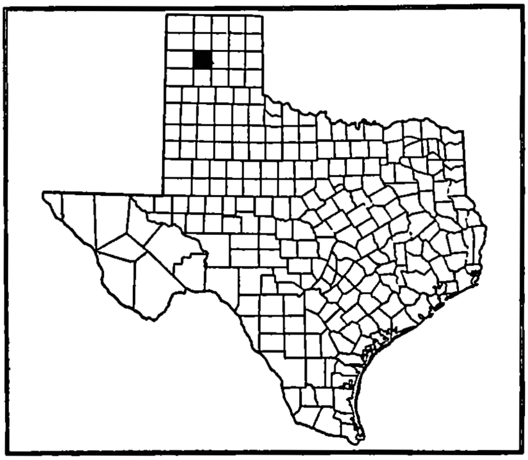


FIGURE 1.—Sketch map showing location of Potter County, Tex.

Physiographically the county is comprised of three divisions as follows: (1) A narrow southern rim and southeastern triangle of flat, elevated plateau-like country—a part of the High Plains, or Llano Estacado; (2) a central east-west valley of rough country constituting the north and south slopes to Canadian River which flows eastwardly through the central part of the county, including a part of the Canadian River breaks; and (3) a smaller northern rim of flat plateaulike country identical in features to the southern rim—a part of the High Plains or Panhandle High Plains. Figure 2 shows the location of these divisions.

The small areas of the High Plains included within Potter County are a small part of a great plain covering a large area in the western part of Texas, Oklahoma, Kansas, and Nebraska. The High Plains constitute a plain of constructional relief—a remnant of a great debris apron spread eastward from the base of the Rocky Mountains. The High Plains occupy an elevated plateau position surrounded on the east and south by lower rolling plains. The boundary to the lower rolling plains is marked by a cliff or sharp slope protected by an indurated bed of caliche, or cap rock. The caliche has a maximum thickness of more than 20 feet and lies about 50 feet below the general level of the High Plains, although in places, as around the heads of East Amarillo Creek, it is only slightly developed and inconspicuous.

The surface of the High Plains is dotted by numerous enclosed flat-bottomed depressions, the low parts of which are occupied by intermittent lakes, or playas. These depressions reach a maximum size of several square miles, and most of them consist of three parts: (1) A central low flat, occupied by an intermittent lake bed constituting from one-fourth to one-half of the total area of the depression; (2) a surrounding concentric poorly drained flat usually known as "second bottom"; and (3) an outer surrounding slope,

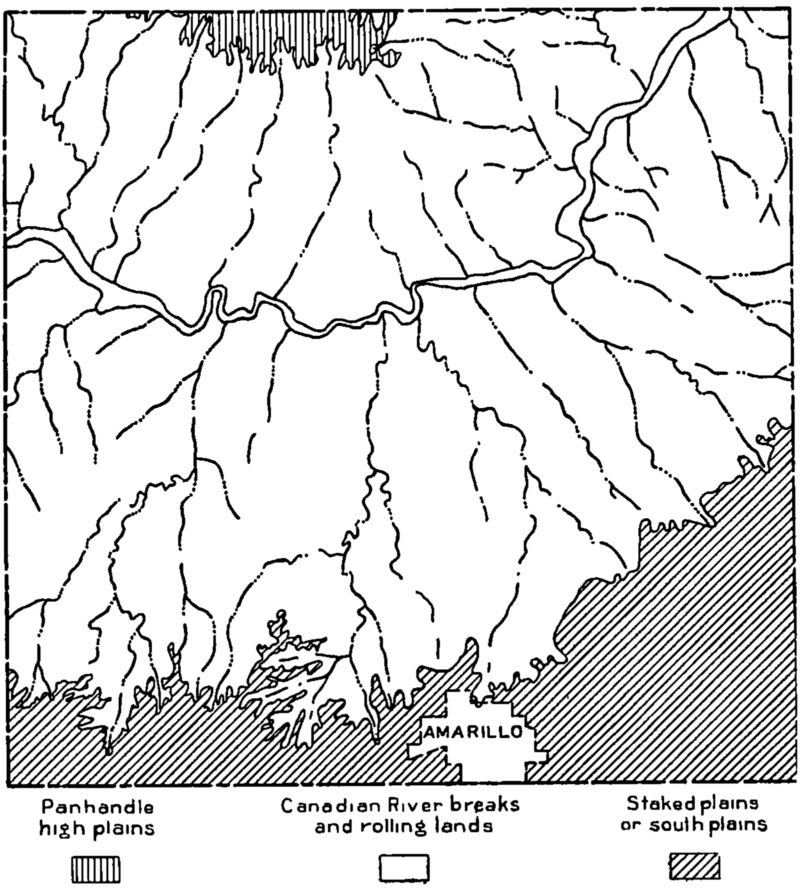


FIGURE 2—Physiographic divisions of Potter County, Tex

from one-eighth to one-fourth mile wide, with a gradient sufficiently steep to cause some soil erosion. These depressions occur at intervals of about 2 or 3 miles and constitute about one tenth of the total area of the High Plains in Potter County. In the county the High Plains lie at an elevation ranging from 3,500 to 3,800 feet above sea level.

The "Canadian River breaks" is the common name given the hilly belt on both sides of Canadian River Valley in its course across the High Plains. This valley is about 25 miles wide, and its lowest part, which is occupied by the bed of the river, in Potter County lies about 700 feet below the level of the High Plains. The surface relief within the Canadian River breaks is in general strongly rolling or hilly. A few interstream areas have comparatively smooth surfaces, but the greater part of the land is too rough for cultivation.

That part of the High Plains in Texas north of Canadian River is known as the Panhandle High Plains, or north plains, and the part south of the river, as the Staked Plains, Llano Estacado, or south plains. These parts in reality constitute one physiographic unit, being separated from each other by the great trench of the Canadian River Valley. The greater part of Potter County lies within the Canadian River breaks, small parts only being in the Staked Plains and the Panhandle High Plains.

Although there are practically no streams on the High Plains of northwestern Texas, except the few large streams which cross them in deep valleys, the soils are in general well drained. The small basins, or sinks, constitute drainage outlets for the broad, smooth plains areas.

Drainage of the Canadian River breaks is thorough. Generally speaking, the soils within the valley would have a higher agricultural value if they were less sloping and less well drained. Throughout much of the valley dissection and erosion have been so excessive as to entirely unfit the soils for crop production. Drainage of the Canadian River breaks is controlled by Canadian River as the master stream, which flows eastwardly across the central part of the county. It is a perennial stream having its source in the Rocky Mountains in northeastern New Mexico. The bed of the river ranges from one-fourth to 1 mile wide and is filled and choked with a constantly shifting deposit of sand and quicksand, which in places at least is more than 100 feet thick. During normal stages the river meanders over the sand bed in constantly shifting, braided channels, most of which are about 100 feet wide and from 2 to 3 feet deep. During extended dry spells the river dries to isolated pools, and during flood stages the bed is covered with many feet of swiftly moving water.

Canadian River has no large tributaries in Potter County, and the smaller streams flow at right angles to the course of the river. Most of the laterals to the tributaries are short, and the result has been that the county is carved into a large number of narrow north-south valleys. Nine such valleys are north of the river and 11 south of it. These valley basins extend back to the edge of the High Plains and average about 3 miles wide and 10 miles long.

The tributary streams are fed by springs originating at the base of the High Plains deposits. The water from most of the springs disappears within a short distance into the sand beds which fill the stream channels, but water is available for livestock over much of the Canadian River breaks. Some of the springs are of good strength and maintain their flow during the most protracted dry periods, the strongest being those at the heads of Tecovas and West Amarillo Creeks. The water of these springs is well suited for irrigation and has been thus utilized to some extent.

The vegetation on the High Plains consists of an almost pure stand of the short grasses, buffalo grass and blue grama occurring in a proportion of about 3 to 1. Rosinweed is the only other plant which is at all abundant on smooth areas. On areas of shallower soils on the High Plains, whitetop, needlegrasses, buffalo pea, and various other annual legumes grow in considerable profusion. In locations where the native sod has been disturbed, needlegrasses, whitetop, fetid marigold, gumplant, Texan crabgrass, redroot, wild barley, Russian-thistle, and scarlet gaura are common. In and around lakes and buffalo wallows the vegetation includes blueweed, ironweed, blazing-star, water grass, and a few other growths. In places sweetclover, an introduced plant, grows as a roadside weed.

In cultivated fields the only two serious weed pests are blueweed and Johnson grass. Other common field weeds are redroot, lambsquarters, Russian-thistle, winter grass or wild barley, Texan crabgrass, fetid marigold, and a few others. Fields allowed to revert to pasture are covered with the common field weeds for 2 or 3 years, after which needlegrasses and whitetop become more abundant, with fetid marigold remaining longer than the other field weeds. The native buffalo-grass and blue-grama sod is restored within a period ranging from 10 to 50 years, depending on whether cultivation entirely removed these grasses from the field and afforded no opportunity for reseeding. Fair pasture is obtained after the land is left out of cultivation from 2 to 5 years.

The vegetation within the Canadian River breaks is much less uniform than that in the High Plains, although it is predominantly grass. The chief difference is the abundance of little bluestem and other tall grasses. In this section, areas of smooth upland soils support the same type of vegetation as that of the High Plains, together with some scrubby mesquite brush, winterfat, and woolly loco.

Shallow soils support a characteristic growth of little bluestem with smaller quantities of blue grama, black grama, needlegrasses, catclaw, one of the evening primroses, one of the candyroots, purple loco, and various other plants.

The vegetation of very sandy areas is characterized by little bluestem, big bluestem, and sand sagebrush, together with smaller quantities of ill-scented sumac, wild plum, sandgrass, Indian grass, switchgrass, needlegrasses, yucca, wormwood, sawbrief, ragweed, black grama, blue grama, and many other plants.

Areas of bottom land support a very mixed vegetation including blue grama, low mesquite brush, saltgrasses, bottom grasses, annual sunflower, a few cottonwood trees, and many other plants.

During the course of the soil survey specimens of plants were collected and submitted to V. L. Cory, range botanist of the Texas Agricultural Experiment Station, for identification. The following list gives the scientific and common names of the plants collected:

Scientific name	*Common name*
Actinea scaposa linearis	None.
Ambrosia psilostachya	Perennial ragweed.
Agropyron tenerum	Water grass or slender wheatgrass.
Andropogon furcatus	Turkeyfoot or big bluestem.
Andropogon saccharoides	Silver beardgrass or whitetop.

Scientific name	*Common name*
Andropogon scoparius	Prairie beardgrass or sage grass
Aristida fendleriana	Fendler three-awn.
Aristida glauca or A. purpurea	Three-awn.
Aristida longiseta	Red three-awn.
Artemisia dracunculoides	False tarragon
Artemisia filifolia	Sand sagebrush
Astragalus mollissimus	Woolly loco
Bouteloua curtipendula	Side-oats grama
Bouteloua eriopoda	Black grama
Bouteloua gracilis	Blue grama
Bouteloua hirsuta	Hairy grama.
Bulbilis dactyloides (*Buchloe dactyloides*)	Buffalo grass, locally miscalled mesquite grass.
Calamovilfa longifolia	Prairie sandreed
Ditaxis neomexicana	None.
Dyssodia papposa	False dogfennel or fetid marigold.
Elymus glaucus	Blue wild-rye.
Eragrostis lugens	None.
Eragrostis pectinacea	Do.
Eriogonum triste	Do.
Eurotia lanata	Winterfat.
Euphorbia marginata	Snow-on-the-mountain.
Grindelia squarrosa	Gumplant.
Gaura coccinea	Scarlet gaura.
Gutierrezia sarothrae	Rosinweed, broomweed, or snakeweed.
Helianthus annuus	Common sunflower.
Helianthus ciliaris	Blueweed or blueweed sunflower.
Houstonia polypremoides	None
Ipomoea leptophylla	Bush morning-glory.
Juniperus monosperma	Cherrystone juniper.
Laciniaria punctata (*Liatris punctata*)	Dotted gayfeather or blazing-star
Leptoloma cognatum	Fall witchgrass
Leptoglottis nuttalii	Sawbriar
Mimosa borealis	Catclaw.
Muhlenbergia repens	Creeping muhly
Munroa squarrosa	False buffalo grass
Oenothera serrulata	Evening primrose.
Oreocarya suffruticosa	None.
Oxytropis lambertii	Crazyweed or purple loco
Panicum bulbosum	False Johnson grass
Panicum obtusum	Vine-mesquite grass or wire grass
Panicum virgatum	Switchgrass.
Parosela enneandra	None
Parosela formosa	Feather peabush
Phragmites communis	Reed (Carrizo, the Spanish name).
Polygala alba	Candyroot
Polygonum lapathifolium	Pale ladysthumb or smartweed.
Rhus trilobata	Lemonade sumac or ill-scented sumac.
Salsola pestifer	Russian-thistle.
Schedonnardus paniculatus	Tumblegrass or Texan crabgrass.
Scutellaria wrightii	Skullcap.
Senecio longilobus	Woolly groundsel
Senecio riddellii	Riddell's groundsel.
Sophora sericea	None.
Sorghastrum nutans	Indian grass
Sphaeralcea coccinea	Red false mallow.
Sporobolus airoides	Alkali saccaton, locally known as saltgrass
Sporobolus contractus	Rattail dropseed.
Stillingia salicifolia	None
Triodia pilosa	Do.
Vernonia marginata	Ironweed.
Vicia texana	Texas vetch.

According to the 1930 census,[1] the population of Potter County is 46,080. Amarillo, the only city and county seat, has a population of 43,132, a small part of which is in Randall County. The farm population is concentrated largely on the High Plains south of Canadian River and in some of the smoother parts of the Canadian River breaks a few miles north of Amarillo. The population, especially the farm population, consists largely of native whites from the older sections of Texas and the Midwestern States. A few negroes and Mexicans reside within or adjacent to Amarillo.

Amarillo is the principal city, trading center, and shipping point, and is a railway center having excellent railway transportation facilities in all directions. The railways entering Amarillo are the Panhandle & Santa Fe, the Fort Worth & Denver City, and the Chicago, Rock Island & Gulf. Hard-surfaced highways enter this city from the north, west, south, southeast, east, and northeast. The county roads, with the exception of a few on the High Plains in the southern part of the county, are ungraded ranch trails. The trails leading to the main ranch headquarters are in fair condition and are nearly always passable, but most of the roads and trails branching out from the main branch headquarters are in poor condition and are often impassable for automobiles. Many parts of the county are several miles from a road or trail of any sort.

Amarillo is the principal local market for farm products, having within its limits several elevators, a flour mill, two creameries, and many grain and produce houses. This city also furnishes a good market for whole milk, fresh vegetables, poultry, and other farm products. In addition to those in Amarillo, grain elevators are located at Pullman, St. Francis, and Bushland. Kansas City is the principal cattle market for the livestock raised.

The principal industrial enterprises are wholesale and retail marketing and distribution, railway shops, a zinc smelter, United States Bureau of Mines helium plant, oil and gas production, oil refinery, cottonseed-oil mills and flour mills.

CLIMATE

The climate of Potter County is subhumid, with moderate temperatures. The principal influences which affect crop production are (1) a limited annual precipitation with irregular seasonal distribution accompanied by a great loss of water on sloping areas, caused by run-off during torrential summer storms, (2) a very high rate of evaporation, (3) a relatively low atmospheric humidity, (4) a high average wind velocity, and (5) hot summer days followed by cool nights, and moderate winters with some severe cold spells.

The mean annual precipitation during the 51 years of record, 1882 to 1932, inclusive, at the United States Weather Bureau station at Amarillo, is 21 01 inches. During this period the total yearly rainfall has ranged from a maximum of 39.75 inches in 1923 to a minimum of 11.15 inches in 1910. There is a wide fluctuation in the annual precipitation, it being about 50 percent more variable than in the older agricultural sections. The more important climatic data are set forth in table 1.

[1] Soil survey reports are dated as of the year in which the field work was completed Later census figures are given when possible

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

[Elevation, 3,676 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1923)	Snow, average depth
	°*F*	°*F*	°*F*	*Inches*	*Inches*	*Inches*	*Inches*
December	37 0	77	−2	0 80	(1)	1 11	5 7
January	35 3	82	−11	51	0 05	00	3 8
February	38 1	84	−16	73	17	1 71	4 7
Winter	36 8	84	−16	2 04	22	2 82	14 2
March	46 9	96	−2	71	34	2 97	2.0
April	55 8	94	6	1 83	59	3 22	1 1
May	64 1	98	26	2 79	2 99	1 70	3
Spring	55 6	98	−2	5 33	3 92	7 89	3 4
June	72 8	106	38	2 84	66	9 76	0
July	76 8	102	51	2 84	3 57	1 85	0
August	75 7	102	48	3 08	2 19	1 54	0
Summer	75 1	106	38	8 76	6 42	13 15	0
September	69 3	101	36	2 30	05	6 42	0
October	57 7	94	15	1 66	26	7 34	7
November	45 5	85	4	92	28	2 13	2.4
Fall	57 5	101	4	4 88	59	15 89	3 1
Year	56 2	106	−16	21 01	11 15	39 75	20 7

[1] Trace

Distribution of the average annual rainfall is very favorable, about 75 percent of the total being received during the period from April to September, inclusive, but the actual distribution is irregular and much less favorable. Occasionally during several months in succession no effective rainfall is received, and crop yields are materially reduced. A relatively low annual rainfall, properly distributed, may produce a good crop in the same field where a much higher rainfall, with unfavorable distribution, may result in crop failure or low yields. Hence, records of annual and monthly precipitation may easily be misleading because of the great importance of distribution.

The average relative humidity is low. During the 30 years prior to 1920 the average annual relative humidity at Amarillo, at 7 a.m. was 76 percent and at 7 p.m. was 47 percent (*19*).[2] The mean seasonal evaporation (April to September, inclusive) from an open water surface during the period 1907 to 1919 inclusive was 52.08 inches (*3*). This is a high rate of evaporation. According to Kincer (*14*) an increase of 3 inches in seasonal evaporation is approximately equivalent to a decrease of 1 inch in annual rainfall.

The average annual wind velocity is high, having been 13 miles an hour during the 31 years preceding 1920 (*19*). During the 4-year period from 1907 to 1910, inclusive, there was an average of 14 days in each year in which a wind velocity of more than 40 miles an hour

[2] Italic numbers in parentheses refer to Literature Cited, p 47

was recorded (*2*). For comparison, the average wind movement at Dallas (*18*) was 9.4 miles an hour, and in central Illinois (*17*) was 8.9 miles an hour. The prevailing wind direction is from the southwest. High winds often cause damage to crops by quickly evaporating the soil moisture, by covering or cutting off the young plants, or by blowing down the crop when it is almost mature.

The annual average snowfall at Amarillo during the 29 years prior to 1920 was 20.7 inches. The snow generally melts within a few days. Hail occasionally causes crop damage in local areas.

Temperatures ranging from 0° to −16° F. occur occasionally during the winter, especially during February. In general, the winters are moderate, with occasional severely cold snaps which are locally termed "northers." Many days occur during the winter when outdoor work may be pursued without discomfort. The daily range in temperature is great. In general, the days in summer range from warm to hot, and the nights are cool. As a whole, the climate is healthful and invigorating.

The average length of the frost-free season at Amarillo is 201 days. The average date of the last killing frost is April 13 and of the first is October 31. The latest recorded killing frost occurred on May 23 and the earliest on September 22.

The relationship between climate and soils is such that winter wheat and grain sorghums are the best-adapted staple crops. Winter wheat is sown in the fall near the end of the wettest part of the year, when there is generally sufficient moisture in the soil to germinate the seed and start a good growth before the comparatively dry winter season begins. The crop is matured with the spring and early summer rains, and the precipitation received following harvest is conserved, if the land is farmed correctly, and stored in the soil for fall seeding of the next year's crop. Accordingly, winter wheat starts growth and matures the crop during comparatively moist seasons and passes through the dry season in a relatively dormant stage. Spring grains, on the other hand, must be seeded during the late winter, which is the driest season of the year, and at a time when the soil frequently contains insufficient moisture to germinate the seed and start growth. As a rule, almost as much moisture can be stored in the soil during the period following harvest and preceding winter-wheat planting as can be stored in a complete season of fallow. Therefore, the usual and apparently most profitable method of wheat farming is to crop every year rather than to crop in alternate seasons with fallow.

Grain sorghums and sorgo are very drought-resistant crops, and they are very well adapted to climatic conditions in Potter County. They are able to withstand the conditions much better than corn. On the sandier soils which are somewhat more drought resistant, yields of corn more nearly approach those of the grain sorghums.

The average temperature is somewhat too cool for successful production of cotton under present conditions. According to Kincer (*14*) cotton requires a mean summer temperature of 78° F. and a 200-day growing season for profitable production.

AGRICULTURE

Potter County and the surrounding territory were first laid out in large ranches about 1875. Prior to this time the land was occupied by the Indians as a hunting ground. The early ranches comprised thousands of acres each, and the only settlements consisted of the few persons living at the various ranch headquarters or railroad camps. Cattle thrived on the nutritious native grasses and endured the winter with the protection afforded by the rougher areas. At first the High Plains were ranged only during the wetter periods when water was available in the various lakes, and the "breaks", with its numerous springs, was relied on for permanent grass and water supply. Later, wells were drilled on the High Plains, and that section was used more extensively.

No crops were grown by the early ranchers, and the native grasses were depended on entirely as livestock feed. In dry seasons, when the pasturage was short, and in very cold winters great losses resulted from death of the cattle which were thin and in poor condition. To avoid this loss, it became customary to provide some feed to carry the cattle over the winter. Wild hay, cut chiefly from lake beds or bottom lands, and sorgo were first utilized for this purpose, and later cottonseed cake and grain sorghums were used.

About 1905, farming, as an enterprise separate from ranching, began to assume importance, and some of the ranches were broken into parcels including a section or two, a size suitable for farming. This process has continued, settlement has steadily increased, and a constantly increasing proportion of the land is being devoted to crop production.

Full information in regard to the early agricultural history of this general region may be obtained from the Panhandle Plains Historical Society, in care of the West Texas State Teachers' College, Canyon, Tex.

The average-sized crop farm consists of 1 section (640 acres) of land, but many farms include one-half section, others as much as 2 or 3 sections. The trend is somewhat toward smaller farms. The livestock ranches are very large and include many square miles, two thirds or more of the county being included in 11 ranches.

According to the 1930 census, of the 322 farm operators, 183 are owners or part owners, 109 are tenants, and 30 are managers. Of the 109 tenant farmers, 39 are cash tenants and 70 are share tenants. About one-half of the 42,546 acres of crop land harvested in 1929 was in tenant farms. The common crop-share agreement is for the owner to receive one-third of all the crops, with the tenant furnishing all equipment and delivering the wheat to the elevator. On a cash basis, the rent is a composite of three factors which include a lease of the improved land at $1 to $2 an acre, plus the grassland at 35 to 50 cents an acre, plus up to 10 percent of the value of the improvements. Grassland leases in large ranches range from 30 to 50 cents an acre.

The farm buildings commonly consist of a one-story house, a small barn with limited storage capacity for feed, a small poultry shed, a hog shed, and possibly a well house or dairy house.

The farm machinery owned by the average farmer handling one section of land includes a 15- to 30-horsepower tractor, a truck or automobile, an 8-foot cut one-way wheatland plow, a 3- to 4-foot cut disk plow, a 16-foot combine, a 20-disk 8-inch drill, and a variety of smoothing harrows, cultivators, listers, moldboard plows, and hand implements.

Commercial fertilizer purchases are confined to very small amounts which are used on gardens and lawns.

SOILS AND CROPS

The soils of Potter County comprise five general groups as follows: (1) Good agricultural soils, mainly heavy in texture, suited to the production of small grains; (2) moderately productive agricul-

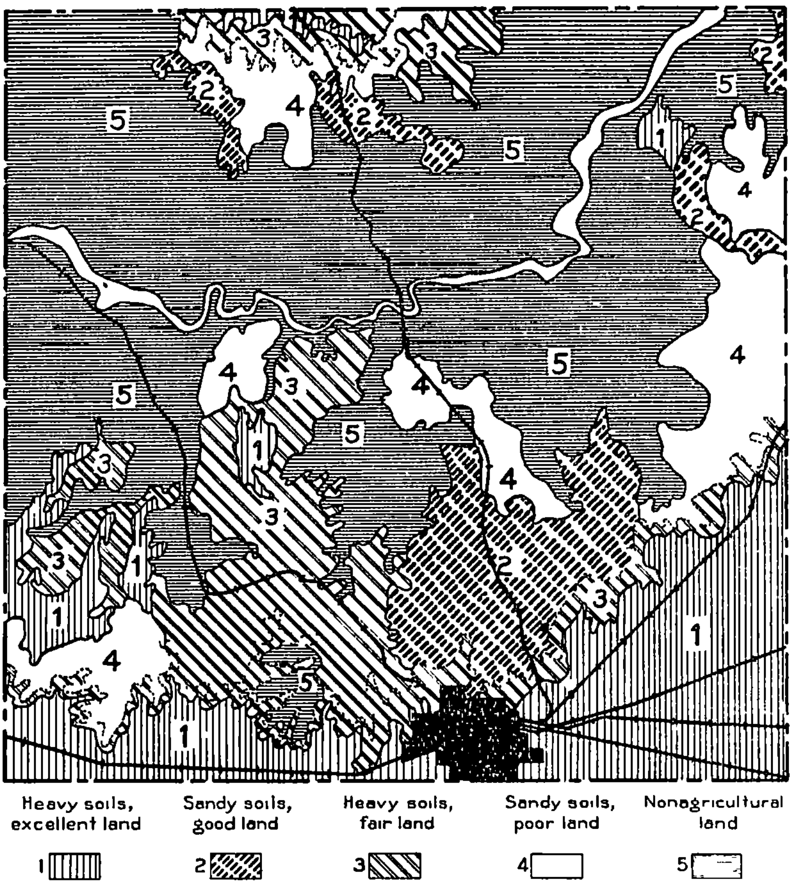


FIGURE 3.—Generalized map showing distribution of soil groups in Potter County, Tex., according to their productivity.

tural soils, sandy in texture, not well suited to the production of small grains; (3) heavy, moderately good agricultural soils; (4) sandy, poor agricultural soils; and (5) nonagricultural land. The accompanying sketch map (fig. 3) shows the distribution within the county of these general soil groups.

The heavy excellent agricultural soils well suited to the production of small grains dominate farming in the county. They occupy those parts of the county lying on the High Plains and small areas within the valley of Canadian River. Soils of this group comprise 27.2 percent of the total area of the county, and in 1928, 90 percent of all the land in crops was on these soils. These are the best soils in the county for the type of farming (predominantly the production of winter wheat) prevalent in this section. The characteristics of the soils, which give them superior agricultural value, are their comparatively heavy texture, good content of plant food, and smooth surface relief.

The heavy texture renders the soils (with proper tillage) comparatively immune to blowing during the high winds of winter and spring. Such immunity is the factor which makes a heavy texture valuable, because where the surface soil is very loose or pulverized during the dry period of winter and early spring before the young grain has started vigorous spring growth to offer protection, wheat and other winter-grain fields are often severely injured or entirely ruined through soil drifting. The soil is blown away, exposing the roots, so that either the entire plants are uprooted, or they may be cut off just above the surface of the ground The heavy texture, especially where associated with compact subsoils, as in Pullman silty clay loam, renders these soils rather slowly permeable by water and therefore somewhat droughty. It is probable that the ideal soil for the climatic and agricultural conditions of Potter County is a friable clay loam, such as Zita clay loam.

Experimental results on Pullman silty clay loam and farming experience on all the soils of this group indicate that they contain in their present condition all the available plant food which crops are able to utilize with the amount of moisture they normally receive. In other words, water supply, and not fertility, is practically always the limiting factor in crop production on these soils. Farmers state that fields which were broken out from 20 to 25 years ago and which have been cropped ever since, largely to wheat, yield as well as freshly broken land, and that no reduction in yields due to lessening of fertility has been observed, though a few old fields have been damaged through infestation by blueweed or Johnson grass. In their virgin condition these soils carried a good supply of available plant food, and the agricultural development of the region is so recent that to date the soils have given little response to crop rotation or fertilization. However, it is undoubtedly good practice to save whatever barnyard manure is available and to spread it thinly over the land.

These soils are not acid, and they are well supplied with lime. The addition of lime would not be beneficial and might be detrimental by providing conditions that favor chlorosis.

The smooth surface relief of these soils is valuable, not only aiding in the conservation of rain water, but because it allows large units of land to be worked with power machinery.

Table 2 shows the proportions of the soils of this group in cultivation in Potter County in 1928.

TABLE 2.—*Extent and utilization of the good agricultural soils, mainly heavy in texture, in Potter County, Tex., in 1928*

Soil type	Total area	Area in crop land	
	Square miles	*Square miles*	*Percent*
Pullman silty clay loam	101.2	75.8	74.9
Pullman silty clay loam, shallow phase	28.5	5.0	17.5
Pullman clay loam	66.5	2.5	3.8
Richfield silty clay loam	2.9	1.7	58.6
Richfield clay	2.2	1.5	68.2
Richfield clay, calcareous phase	3.3	.8	24.2
Zita clay loam	14.3	.9	6.6
Spur clay loam	8.2	1.2	14.6
Spur fine sandy loam	9.1	.8	8.8
Miller clay loam	4.6	0	.0
Miller clay loam, colluvial phase	2.3	0	0
Yahola fine sandy loam	4.3	0	0
Yahola loamy fine sand	2.6	0	0
Total	250.0	90.2	36.1

The alluvial soils of this group include Spur clay loam, Spur fine sandy loam, Miller clay loam, Miller clay loam, colluvial phase, Yahola fine sandy loam, and Yahola loamy fine sand. All these soils, except Yahola fine sandy loam and Miller clay loam, colluvial phase, are in general very good soils. They are subject to occasional overflow, but the inundations are generally beneficial rather than detrimental, because they supply good stores of soil moisture. The colluvial phase of Miller clay loam is somewhat sloping and eroded, which detracts from its value for farm land. Yahola loamy fine sand is so loose and drifts so badly in winds that it is generally unsuited to farm crops. The heavier soils are productive and are about equally suited to the same crops. The crops grown are about the same, though crop yields are somewhat higher than on the sandy moderately productive agricultural soils of group 2. On account of the extra moisture which these soils occasionally receive as overflow, they are somewhat better suited to certain special crops, such as alfalfa and corn, than the soils of group 2. A few small areas have been irrigated successfully with water diverted from adjacent streams.

Most areas of the bottom-land soils occur as small patches surrounded by nonagricultural land and accordingly are used as grazing land. They furnish very good grazing, about twice as much as the upland soils, and because of their sheltered locations are especially valued for winter pasture. They support a heavy growth of grasses and other plants. Some native grass is cut for hay.

For the most part the surface relief of these soils is smooth, and the land could readily be leveled for irrigation.

The soils of the second general group, the sandy moderately productive agricultural soils, occupy only 6.1 percent of the county. They occur as gently sloping areas within the Canadian River Valley, the most extensive of which is immediately north of Amarillo. Because of their occurrence in association with rough land, they are utilized largely for ranching. In 1928, only 4.5 percent of their total area was in cultivation. These soils are adapted to a mixed type of farming concerned primarily with the production of feedstuffs and the feeding of livestock rather than a small-grain type, such as prevails on the soils of the first group. They are better adapted to the production of grain sorghums and other row crops than they are to the production of winter wheat, as they are too loose and subject to blowing to be good small-grain soils. Even in years when there is no damage from soil blowing, yields of small grains are only about two thirds as large as those obtained on the heavy soils of group 1. On the other hand, the soils of group 2 produce higher average yields of grain sorghums and other row crops than do the soils of group 1. They are more permeable by water and are more drought resistant. They are smooth deep fertile soils which are very productive for crops other than small grains.

The soils of the third general group, the heavy moderately good agricultural soils, comprise 9.4 percent of the total area of the county. In 1928, 2.8 percent of their area was in cultivation. These are sloping shallow soils of comparatively low productivity, being only about one-half as productive as the soils of group 1. They are marginal wheatland. Under present agricultural conditions they should not generally be placed in cultivation. The farmed areas are urgently in need of terracing or other methods of controlling erosion.

The soils of the fourth general group, the sandy, poor agricultural soils, comprise 12.7 percent of the county's area. They lie within the valley of Canadian River and are shallow or very sandy soils. They are submarginal land for crop production and should continue to be utilized as ranch land. In 1928, less than 0.1 percent of their total area was in cultivation. However, they could be farmed, and the most suitable crops would be grain sorghums and other row crops similar to those adapted to the soils of group 2.

A large proportion, 44.6 percent, of the area of Potter County, including most of the valley or "breaks" of Canadian River, consists of land which is nonagricultural, in the sense that it is unsuited to the growing of cultivated crops. Land of this character constitutes the fifth general group of soils. Some of this land is rough, some shallow and severely eroded, some extremely sandy and loose, some covered with water for extended periods, and some contains a large quantity of gravelly or stony material. The nonagricultural land is held in large ranches and utilized, with the exception of river wash, for grazing livestock. It constitutes good to excellent ranch land.

Farming in Potter County consists of three types—large-scale wheat farming on most of the soils of group 1, general crop farming on parts of the soils of groups 1 and 2, and livestock ranching on the rest. About 15 percent of the land is devoted to wheat farming, about 10 percent to general farming, and about 75 percent to livestock ranching.

In the large-scale wheat farming, wheat occupies from 75 to 100 percent of the cultivated land and constitutes practically the sole source of farm income. Very little livestock is kept, and for the most part tillage operations are performed with tractor-drawn implements. This type of farming is characterized by poor distribution of labor, as during about half the year there is no farm work to be done. There are all gradations between this type and the general-crop type of farming.

In the general-crop type of farming, the principal farm enterprise is the production of feedstuffs which are largely fed to livestock. Some grain sorghums are sold, and some winter wheat is produced as a supplemental cash crop. The farming operations are performed largely with horses or mules. This is a more self-sufficing type of agriculture which entails much smaller cash expenditure. Although this kind of farming is at present inextensive, it seems that the logical agricultural development on the good soils of the county would be away from the strictly one-crop wheat farming toward this type. The production of winter wheat should continue as the principal farm enterprise on the heavy excellent agricultural soils well suited to small grains, but this crop has been overproduced, and it should be replaced in part by feedstuffs. A few dairy and truck farms are in the vicinity of Amarillo.

Ranching is almost exclusively cattle ranching, although one ranch has several thousand sheep. Nearly all the ranch cattle are high-grade Herefords. This section of Texas is commonly considered a very good steer country, but the winters are somewhat too severe for raising brood cows without shelter. On most ranches a few cows are kept for breeding, and some steers and other young cattle are brought in for grazing. The steers come through most winters in fair shape with little if any supplemental feeding when placed in some of the rougher more protected ranges where the grass is good. Cattle on the less-protected ranges require some extra feed during the winter in addition to the native grasses. In fact, a ration of cottonseed cake is commonly fed to practically all cattle during the winter. Some of the sorghums or other home-grown feedstuffs are sometimes fed to a limited extent.

For grazing purposes the rough nonagricultural land is as valuable as the flatter better agricultural land of the High Plains, because the broken areas afford better protection in winter, and the coarser higher growing vegetation affords range forage when the short grasses are covered with snow. Ranchers state that the rough land will support about the same number of cattle as the high flat land, with less summer and more winter grazing. The carrying capacity of grazing land in this section is from 25 to 35 head of steers a section (640 acres). For grazing purposes the land leases at prices ranging from 25 to 40 cents an acre per annum.

Although woolly loco, purple loco, and a few other poisonous plants grow here to some extent, comparatively little livestock poisoning is reported.

Winter wheat is the most important crop (pl. 1, *A*). According to the 1930 census, about 48.4 percent of the total area of crop land in Potter County was devoted to the production of wheat in 1929. The proportion devoted to the production of winter wheat varies greatly with the season. During the last 5 years, which have been generally good wheat years, the proportion of land in wheat has increased somewhat. If sufficient moisture to germinate the seed and give the young plants a good start is in the ground in the fall, a large acreage is sown to this crop. Conversely, if the soil is so dry in the fall that the prospects are poor, the acreage sown is much reduced, and a larger than normal acreage is devoted to the production of sorgo, grain sorghums, or other crops.

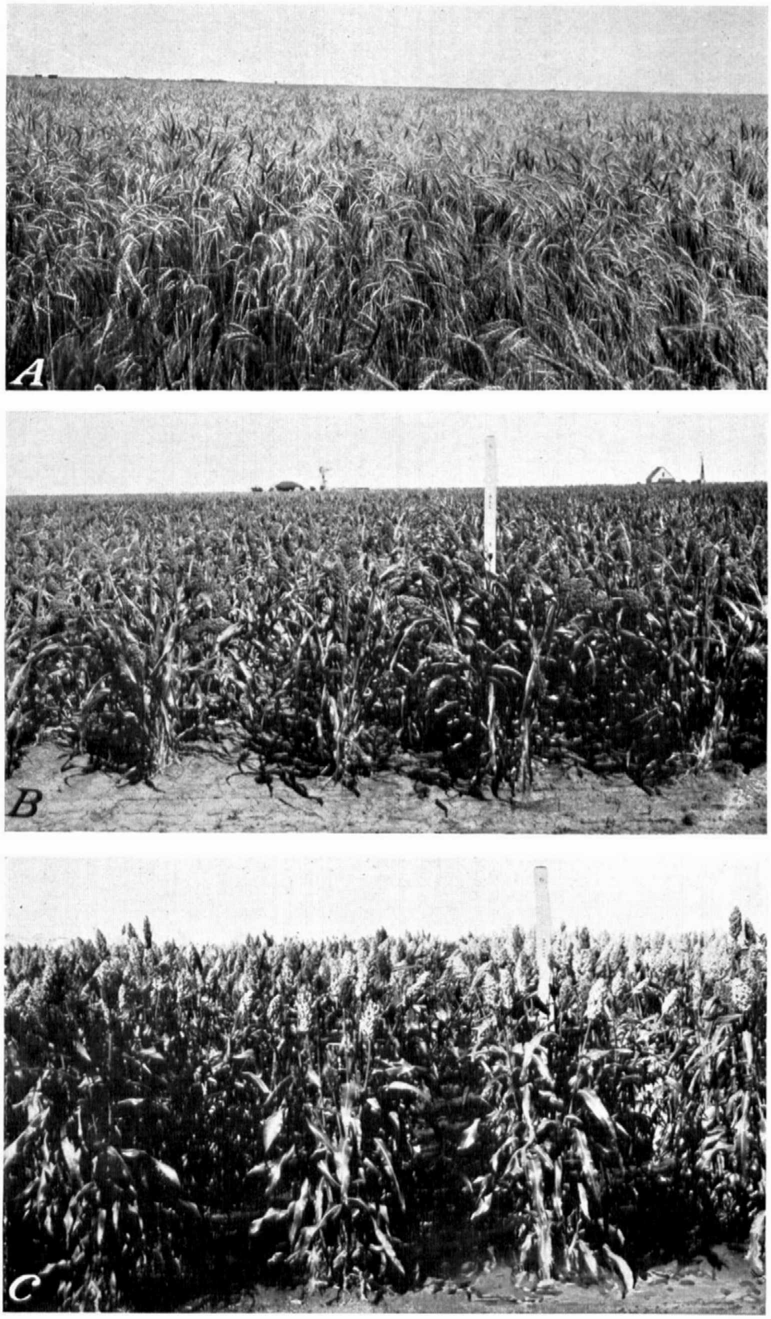
Although figures on the yield of winter wheat over a long period of years are not available, it is very probable, judging from local estimates, that the average acre yield of winter wheat, with good culture, on Pullman silty clay loam in the vicinity of Amarillo, approximates very closely 10 bushels. During the last few years the average acre yield has been raised to about this figure by the adoption of better cultural practices, especially shallow plowing with a one-way plow immediately after harvesting with a combine. The average acre yield of early fall plowed winter wheat on Pullman silty clay loam at the Amarillo field station of the United States Department of Agriculture during the years 1908, 1909, 1911, 1912, 1913, and 1914 was 8.2 bushels (7). During these years the average annual precipitation at the field station was 87.8 percent of the 37-year average. Assuming that the yield was lowered at least proportionally to the annual precipitation, an average acre yield of 9.3 bushels is indicated. Census figures on the production of wheat, which is almost entirely winter wheat, in Potter County, are 16,352 acres, producing 256,170 bushels, or 16 bushels to the acre, in 1919; and 24,429 acres producing 472,106 bushels, or 19 bushels to the acre in 1929. The actual yield of wheat varies widely with the season and culture. During some years, individual fields have produced more than 50 bushels to the acre, and yields ranging from 25 to 40 bushels are common throughout whole communities. On the other hand, in just as many seasons wheat is a total failure, as in 1918. Likewise, the quality of tillage strongly affects the yield as well as the good or poor returns to the farmer in attempting to adapt his tillage operations and time of seeding to a particular season.

Cultural practices in the production of winter wheat in this county and general region are concerned primarily with the conservation of soil moisture. In general-farm practice this is accomplished by immediate working of the land following harvest rather than fallowing and cropping in alternate seasons. As wheat follows wheat more often than any other crop, the crop season begins immediately after the preceding wheat harvest. The common practice, which according to present knowledge is also the best, is to immediately follow the combine harvester with some soil-tillage implement which will destroy weed growth and thus prevent loss of water by transpiration. The one-way wheatland plow has been almost universally adopted for this purpose within the last few years. Many farmers start this tillage operation at the same time they start harvesting, running both combine and wheatland plow in the same field, so that the first plowing is completed within a very short time after the harvesting. Following the first tillage, the amount and time of further cultivation depend on the rains and the accompanying growth of volunteer wheat and weeds. Commonly it is necessary to rework the land once or twice before seeding. For these later operations also, the one-way wheatland plow is generally used. Good farmers attempt to keep the land free from weeds and volunteer wheat with as few cultivations as possible, in order to avoid too much pulverization of the land, which tends to cause excessive soil blowing the following spring.

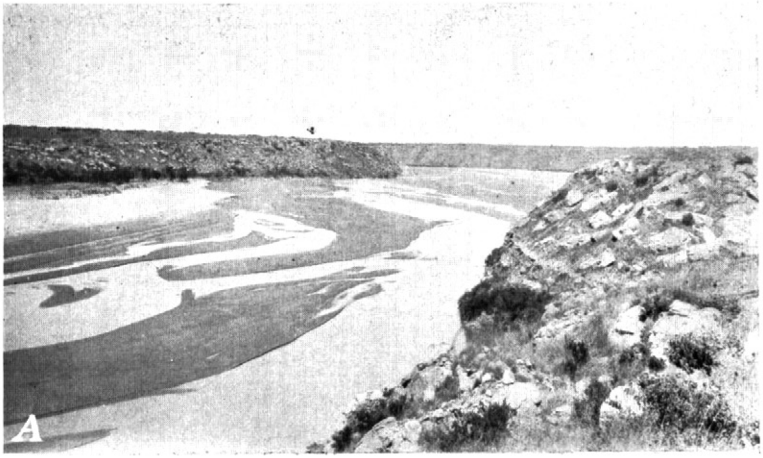
Winter wheat is seeded between September 10 and some time in December or January, October 15 being considered about the best time. A date-of-seeding test, conducted at the Amarillo field station, gave varying results but approximately equal average yields from seeding about October 1, October 15, November 1, and November 15. This test extended over too short a period to be considered conclusive, but it is in line with farmers' experience to the effect that during some seasons one date of seeding is best, whereas during other seasons different dates of seeding are more successful. Nearly every year some wheat is seeded as late as December. It is seeded at a rate ranging from 2 to 6 pecks to the acre, 4 pecks being commonly considered best. Different types of drills are employed for seeding. A very few furrow drills are being used experimentally, but as yet their adaptation or lack of adaptation is not known. Following seeding no further work is generally necessary on the wheat until harvest. A few farmers practice spring harrowing of winter wheat, but this is not generally considered beneficial. One additional operation, which is followed only during seasons when soil blowing is especially severe, is the plowing of furrows in the growing wheat field at right angles to the prevailing wind direction, in order to roughen the surface. When done early and thoroughly enough this will generally stop soil drifting. This operation is necessary only during seasons of high winds in a dry late winter and early spring, when the wheat has not made sufficient growth to protect the surface. Wheat is harvested almost exclusively with combines. These machines have come into use only within the last few years.

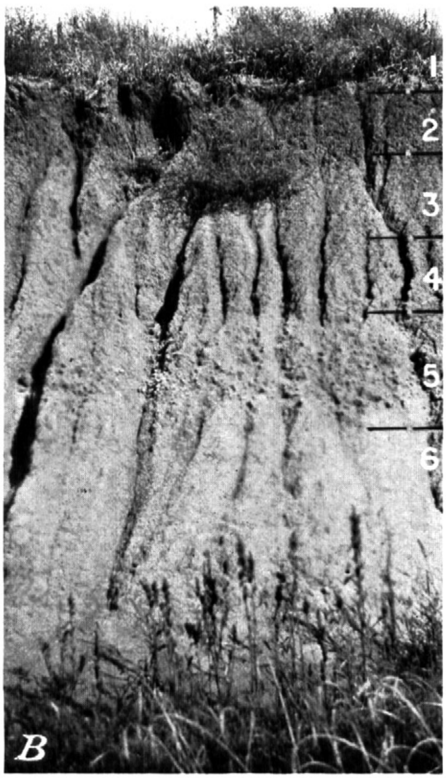
Tractors and tractor-drawn implements are used extensively in the production of wheat. Farmers who grow wheat exclusively use tractors only—no mules or horses—but there are very few such operators. Most of the farmers devote a large acreage to row crops, and they keep some livestock, including some horses. Little or no difficulty is experienced with poor footing, or packing, of the soil with the tractors, as generally, when the soil is too wet to allow the use of a tractor, it is also too wet for plowing or other tillage. A standard 15- to 30-horsepower tractor pulling a one-way wheatland plow cutting from 3 to 4 inches deep, under normal conditions on wheat-stubble land covers from 3 to 3½ acres an hour. The same tractor pulling a disk plow cutting from 4 to 6 inches deep, which is employed for sod breaking and occasionally for deeper cultivation, covers from 1¼ to 1¾ acres an hour. The other implements in common use in the production of wheat, a 20-disk 8-inch drill, covering 13 feet, and the 16-foot combine, can be pulled with a somewhat smaller tractor at a rate ranging from 3 to 4 miles an hour.

The culture of wheat in this section is still in a somewhat experimental stage, but, as previously explained, the immediate cultivation of the soil following the preceding wheat harvest is apparently the most profitable method. Cultural experiments at the Amarillo field station during the period 1908–14, using early fall plowing as a standard of comparison, showed a decrease of 1 bushel an acre with late fall plowing, a decrease of 1.3 bushels an acre with disking following corn, a slight decrease with listing instead of plowing, no increase with subsoiling to a depth of 14 inches, no increase with green manuring, and an increase of 2.5 bushels an acre with summer tilling and cropping in alternate seasons. These experiments were



A, Wheat on Pullman silty clay loam, 4 miles east of Amarillo *B*, Milo on Pullman silty clay loam, a cereal field station, Amarillo *C*, Feterita on Pullman silty clay loam, at cereal field station, Amarillo





A, River wash, which occupies the bed of Canadian River Adjacent cliffs are mapped as rough broken land *B*, Profile of Pullman silty clay loam 14 miles northeast of Amarillo The numbers correspond to the layers in the order described on pages 38 and 39 continued until 1919, but the later results are not available. Commenting on these experiments E. C. Chilcott states (*7*):

> * * * the only material difference in the results from different methods has been a small increase in yields on the summer-tilled land at Amarillo This increase in the crop has not been proportionally as great, however, as the increase in the cost of production by the use of this method.

The yield of wheat is generally somewhat greater following wheat than following the grain sorghums or any other crop which continues growing throughout the summer; that is, when the land is properly prepared for wheat. This apparently is owing to the opportunity for the storage of moisture in the soil following the wheat harvest, whereas following other crops which continue growing and using water throughout the summer, the soil is much drier.

The variety of wheat most commonly grown is Turkey, but some Kanred and Blackhull are also grown. Variety tests conducted by the Amarillo cereal field station (*9*) during the period 1906–19 showed Kanred, two strains of Turkey (C.I. 2223 and C.I. 1558), Theiss, and Beloglina as high-yielding varieties, ranking in the order named. The experiments were conducted on Pullman silty clay loam.

Grain sorghums are crops second in importance on Pullman silty clay loam and other High Plains soils. Milo (pl. 1, *B*) and kafir are the two most common varieties, with lesser amounts of hegari, feterita, darso, and a few others. Milo gives higher yields of grain than any of the other grain sorghums. Dwarf Yellow milo is the most popular variety and probably constitutes more than half the total grain sorghum produced in the county. The average acre yield of this variety is between 25 and 30 bushels of threshed grain, and the range is from failure to 75 bushels, though years of complete failure are very rare. One lot of Dwarf Yellow milo yielded at the rate of 92 bushels to the acre at the Amarillo cereal field station in 1915 (*20*). During the period 1908–16 the average acre yield of this variety at this station was 27.1 bushels (*2*). The most important characteristic of Dwarf Yellow milo on Pullman silty clay loam is its outstanding ability to produce good yields of grain. It withstands dry conditions exceedingly well and responds well to more favorable conditions. Milo is planted at any time between May 10 and June 10. Date-of-seeding experiments conducted on Pullman silty clay loam at the Amarillo cereal field station indicated that the normal time of seeding, May 20 to May 25, was the best for Dwarf Yellow milo (*16*). The yields are influenced to such an extent by seasonal conditions that no one date of seeding is best for all years.

Kafir is the grain sorghum second in importance, and its value lies in its ability to produce a high yield of grain and also a good yield of forage. It will not produce so much grain as milo, but the forage is much more abundant and more palatable. The average acre yield of the best-adapted variety, Dawn, at the cereal field station (*2*) during the period 1908–16 was 18.8 bushels. During the period 1913–17 the average acre yield of air-dry forage was 2.29 tons (*20*). The highest acre yield of grain obtained was 70.7 bushels, the highest acre yield of air-dry forage was 5.11 tons, and the lowest yield of forage given good culture was 0.75 ton. This minimum yield illustrates the ability of kafir to produce some forage, as the years 1913 and 1916 were two of the most unfavorable years in the history of the Panhandle. Kafir is seeded at about the same time as milo.

The other grain sorghums are grown to only a small extent. Hegari is probably third in importance, following milo and kafir. It produces good yields of both grain and fodder. Feterita (pl. 1, *C*) is sometimes grown, and experiments indicate that a somewhat later seeding date than for milo and kafir (about June 10) is most favorable for this crop. Certain experiments have indicated that feterita may be slightly more resistant to unfavorable conditions than milo, but feterita has never become very popular in this section.

The methods of preparation of the land for the grain sorghums are somewhat less standardized than for wheat. On Pullman silty clay loam and the associated High Plains soils the grain sorghums generally follow wheat. The two important considerations in the culture of grain sorghums are the conservation of soil moisture and the prevention of soil blowing. The common practice among farmers is to list the land in the early fall and to split the middles with the planter at the time of seeding, so that the seed is placed in the new beds and the old middles. The farmers are not so careful to immediately stop all weed growth following the wheat harvest when preparing for the row crops as when preparing for wheat. This is largely because the soil must be kept rough and cannot be loosened too thoroughly or it will blow badly. Another reason probably is that planting must be delayed until the spring rains, and accordingly the conservation of the fall moisture is somewhat less important than for winter wheat. Sometimes the grain stubble is left undisturbed until spring when it is reworked with the first rain, and seeding must be delayed until the second rain, but this is not considered good practice. On the other hand, very frequently land is prepared for the fall sowing of wheat, and then, if the season is too dry, wheat may not be planted, and the field will very likely be planted to some row crop. To a certain extent the grain sorghums are used as catch crops, when wheat prospects are very poor during the seeding time of the grain sorghums. Experiments conducted at the Amarillo station (*8*) indicated that on this soil the yields of milo and kafir were from 10 to 15 percent greater following small grains than following grain sorghums. This indicates that the moisture stored in the late summer following the wheat crop, or possibly an increase in availability of plant food during the period of comparative fallow, is of material benefit to a following grain-sorghum crop. Spring plowing gave yields approximately 90 percent of those obtained with fall plowing, and listing gave somewhat lower yields than plowing. Summer tilling or fallowing was not so profitable as growing a crop every year.

The sorgos are the crops next in importance on this type of soil in Potter County. Nearly every farmer devotes a small acreage to this crop for the production of forage, and some dairy farmers grow a rather large acreage of sorgo. To a certain extent sorgos are grown as catch crops when the germination of grain sorghums has failed, owing to adverse weather or other conditions and to the fact that it is too late to replant the grain sorghums. Sorgo produces a higher amount of roughage than any other crop grown in the county, the average acre yield of air-dry forage being between 4 and 5 tons. At the cereal field station the Sumac variety produced 10.95 tons of air-dry forage to the acre in 1915 and in a 5-year period from 1913 to 1916, inclusive, which were two of the most unfavorable years in the history of the Panhandle, the yield of Sumac sorgo with good culture, did not drop below 1½ tons to the acre (*20*). This illustrates the dependability of sorgo and its ability to produce forage during the driest seasons. Sumac and Honey are the two most popular varieties, Sumac giving slightly higher yields and a somewhat finer forage. Soil preparation for sorgo is the same as for the grain sorghums, but sorgo may be safely planted much later than the grain sorghums.

Corn is grown to only a very small extent on Pullman silty clay loam and associated High Plains soils in Potter County. Corn, like wheat, which has an opposite relationship, is a crop which shows a very marked adaptation to certain soil characteristics in this section. Corn is entirely unsuited to the heavy soils but is fairly well suited to the better sandy soils. On Pullman silty clay loam and associated heavy-textured soils, corn produces some fodder nearly every year, but creditable yields of grain are reported to occur only about once in 5 years. On this character of land, with equally as good culture, corn will produce approximately one-half as much fodder and one-third as much grain as kafir, one-fourth as much grain as milo, and one-fourth as much fodder as sorgo. In addition, corn is not so safe and sure a crop and does not have the ability to withstand severely unfavorable conditions so well as the sorghum crops. Corn may be grown with some success to produce green corn as a garden crop.

The culture of corn on Pullman silty clay loam was thoroughly tested at the Amarillo station, and the results of these investigations are reported in two bulletins of the United States Department of Agriculture (*6*, *8*). The general results prove that corn is not suited to this soil and climatic region; that the average acre yield with fall plowing following small grain was 5.4 bushels of grain and 1.2 tons of fodder; that corn yielded somewhat better following corn than following small grain; that listing as a soil preparation gave yields about one-fifth better than plowing; and that subsoiling and summer tilling (fallowing) were not of material benefit in increasing the yields.

Oats are a crop of minor importance on Pullman silty clay loam and related heavy-textured soils, which are the only soils on which this crop is grown in the county. Oats are used to some extent as special feed for poultry and other livestock. They produce approximately the same amount of feed as barley or winter wheat and materially less than the grain sorghums (approximately one-fourth as much). They are sown sometime in February after preparation of the land similar to that for winter wheat. The culture of oats on Pullman silty clay loam was studied at the Amarillo station, and the results of these investigations are reported in a Department of Agriculture bulletin (*5*). The general results showed an average acre yield of 17.6 bushels of grain on land fall plowed following small grain, that summer tilling (fallowing) gave an increase in yield of

10 bushels to the acre, that subsoiling and green manuring gave no increase in yields, and that spring plowing gave yields about nine-tenths of those obtained with fall plowing.

Barley is grown to somewhat less extent than oats. Like oats it is used by some farmers to a small extent as feed for poultry and other farm livestock, but the production is very limited. The culture and adaptation of barley are similar to the culture and adaptation of oats, though barley produces slightly more feed than oats. The culture of barley on and its adaptation to Pullman silty clay loam is reported in a bulletin (*4*) which contains some of the results of the experiments with barley on this soil at the Amarillo station.

Sudan grass has proved to be a fairly well suited crop for cattle feed, and it is used to some extent by farmers. It is valuable as a catch crop and is also used for pasture. The yield of Sudan grass compares favorably with that of sorgo.

Alfalfa has been grown by a few farmers. It is not usually considered suited to Pullman silty clay loam and related soils. The chief difficulty is in obtaining a good stand. Some farmers plant alfalfa in the late spring and others in the early fall, but, unless weather conditions are very favorable at the time of planting, poor stands result. The land must be weed free and firmly settled at the time of planting. When good stands are obtained, yields approximate those of sorgo. Alfalfa fields on which good stands have been obtained last from 4 to 7 years, after which various grasses choke out the alfalfa and the field must be plowed or allowed to revert to pasture.

Some cotton has been grown on Pullman silty clay loam but not within the last few years. The cotton that has been grown on this soil about 50 miles south of Amarillo proves that the soil is well suited to the production of this crop, but the growing season is somewhat too short in this section for cotton to be a safe crop. During some seasons the early crop may mature, but in other years frosts occur before any of the crop is ready for harvest. The farmers' experience is that in the present state of development of culture and early-maturing varieties, cotton is not suited to this section.

Broomcorn has been grown to some extent on Pullman silty clay loam by a few farmers. The yields and quality were fairly good, but the acreage devoted to this crop has not become extensive.

With proper care, various fruit trees and garden crops do well on Pullman silty clay loam. Peaches, plums, cherries, grapes, and apples in many home orchards produce fruit for family use. Beans, peas, cowpeas, spinach, turnips, radishes, onions, parsnips, rhubarb, asparagus, tomatoes, lettuce, salsify, beets, and corn are some of the more commonly grown garden crops. Practically all the fruit and garden crops are given some irrigation, generally with water pumped by the windmill which supplies the livestock and household with water. Increase in the production of these home-grown foodstuffs is being strongly recommended by agricultural authorities as one of the most important means of augmenting the farm food supply and income.

Richfield silty clay loam, Richfield clay, and Richfield clay, calcareous phase, occur on the High Plains, associated with

Pullman silty clay loam. They occur as low flats which surround the intermittent lakes, the beds of which are occupied by Randall clay. These soils, which are locally known as "benches", or "bottoms", are seldom covered with water, and they are generally infested with blueweeds which lower their agricultural value. The two heavier soils are difficult to work, are in general somewhat less productive, and therefore are less valued than Pullman silty clay loam. Experienced appraisers estimate these soils at prices ranging from one-half to four-fifths the value of Pullman silty clay loam. In general, those areas lying closest to the lake beds are the least productive. These soils are utilized and cultivated in the same manner as Pullman silty clay loam, though a smaller proportion is farmed, and somewhat more frequent cultivations are required to keep down the weeds. The natural vegetation consists of buffalo grass and blue grama, with a considerable association of blueweed and water grass. These soils have about the same grazing value as Pullman silty clay loam. Occasionally water grass is mowed for hay

Loss of water as run-off constitutes a problem in itself, and the prevention of such loss very probably offers the greatest possibility for the betterment of cultural practices in this section. Results of the erosion and run-off experiments at the Texas Agricultural Experiment Station, substation no. 7, at Spur, Tex., and of the erosion experiment station of the United States Department of Agriculture, Bureau of Chemistry and Soils, at Hays, Kans., should be largely applicable to the vicinity of Amarillo. Results obtained at Spur thus far indicate that level terraces and contour cultivation are best and that large increases in the yields of row crops have been obtained by these means (*10*). It is probable that over much of the land in cultivation in the county, level terracing and contour cultivation would be very profitable.

The effects of soil erosion have not as yet become readily noticeable on most farms, because the land has been in cultivation only a comparatively short time, and the damage occurring in places by sheet erosion is not apparent without close study. In some places a few gullies have begun to form, most of which are in the natural small drains to lakes or adjacent to road cuts. In addition, it must be remembered that in such soils as Pullman silty clay loam, the topsoil layer is shallow over a heavy intractable clay subsoil, and consequently the results of even a slight removal of topsoil might be very serious. There is no doubt that Pullman silty clay loam would be very intractable, probably more droughty, and considerably less productive, if a few inches of the friable topsoil should be lost.

Recommendations for improvement in the utilization of the soils of Potter County consist essentially of recommendations to be a good farmer and a good business man. Good farming, that is, keeping the land weed free and in good tilth with as little expense as possible through the utilization of the proper implements, in the proper way, at the proper time, is the first essential. The country is new, and agricultural practices are not entirely standardized, therefore changes in farming methods must be adopted as they are proved profitable.

In the following pages of this report the soil's of Potter County are described in detail, and their agricultural relationships are discussed; their location and distribution are shown on the accompanying soil map; and their acreage and proportionate extent are given in table 3.

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

Type of soil	Acres	Percent	Type of soil	Acres	Percent
Pullman silty clay loam	04,768	11 0	Fritch fine sandy loam	5,056	0 8
Pullman silty clay loam, shallow phase	18,240	3 1	Potter clay loam	26,432	4 5
Pullman clay loam	42,500	7 2	Weymouth clay loam	28,672	4 9
Richfield silty clay loam	1,856	3	Potter fine sandy loam	59 712	10 1
Richfield clay	1,408	2	Amarillo fine sandy loam, shallow phase	9,216	1 6
Richfield clay, calcareous phase	2,112	3	Enterprise loamy fine sand	5,888	1 0
Fritch silty clay loam	64	1	Rough broken land	206,016	35 0
Zita clay loam	9,152	1 6	Potter gravelly loam	5,632	9
Spur clay loam	5,248	9	Weymouth clay loam, eroded phase	8,640	1 5
Spur fine sandy loam	5,824	1 0	Randall clay	3,072	5
Miller clay loam	2,944	5	Enterprise fine sand, dune phase	24,512	4 2
Miller clay loam, colluvial phase	1,472	2	Dune sand	2,944	5
Yahola fine sandy loam	2,752	5	River wash	11,904	2 0
Yahola loamy fine sand	1,664	3			
Amarillo fine sandy loam	31,040	5 3	Total	588,800	

GOOD AGRICULTURAL SOILS, MAINLY HEAVY IN TEXTURE

Pullman silty clay loam.—Pullman silty clay loam is known locally as "High Plains tight land." It is the important agricultural soil of Potter County and constitutes a very large proportion of the good land. The topsoil is friable silty clay loam from 4 to 6 inches thick. This top layer is dark ash brown in color when dry and very dark brown when moist. It changes gradually to the material beneath. The upper part of the subsoil, which extends to a depth of about 24 inches, is dark chocolate-brown clay, very hard when dry and very plastic when wet. The material in this layer has a redder tinge than the topsoil and is much heavier in texture. Neither the surface soil nor the upper part of the subsoil effervesces with hydrochloric acid, indicating that they contain no free carbonates, but the soil material in these layers is well supplied with lime and is neutral and not acid in reaction. Below a depth ranging from 18 to 26 inches, the lower part of the subsoil consists of calcareous clay which is slightly lighter chocolate brown than the layer above and in places is more red. The red color increases and the dark color decreases with depth, until, at a depth ranging from 30 to 45 inches, the deep subsoil is of a distinctly red shade, ranging from reddish yellow to dull red, is generally not calcareous but may contain a few small concretions of soft white carbonate of lime. At a depth ranging from 40 to 68 inches, averaging 55 inches, beneath flat and gently undulating surfaces, the deep subsoil rests abruptly on soft chalklike material which is commonly known as soft caliche and which consists of pinkish- or yellowish-white soft carbonate of lime. This chalky or soft caliche layer averages 12 inches in thickness and merges downward into a very uniform thick deposit of pinkish-buff highly calcareous friable clay containing a few soft carbonate of lime concretions. This deposit is the parent material.

The topsoil, though hard when dry, when in the proper moisture condition may be fairly easily worked to a very good friable tilth. The subsoil is heavy, sticky, and plastic, when wet, and compact and hard when dry. It is penetrated with difficulty by water, air, and plant roots.

This soil is very uniform. The chief variations consist of slight differences in the thickness, depth, and amount of dark color of the different soil layers. Areas where the chalklike, or soft caliche, layer is less than 3 feet below the surface, with the overlying soil layers thinner and in many places somewhat more red, are mapped as Pullman silty clay loam, shallow phase; and between these areas and the typical soil are various gradations.

A dark-colored variation is known locally as "black land." One area, including about three-fourths square mile, is just east of Soncy. The soil probably contains more organic matter and perhaps is more productive than the typical soil, but crop yields seem to be about the same. This included soil has a surface layer, about 3 inches thick, of very dark brown noncalcareous silty clay loam resting on nearly black plastic clay which, at a depth of about 12 inches, grades below into dark-brown plastic clay. At a depth of about 20 inches the subsoil, which becomes lighter with increase in depth, is brown and calcareous. The deeper subsoil layer is yellowish red at a depth ranging from 30 to 36 inches, and it rests on an impure soft caliche, or chalky, bed at a depth ranging from 4 to 5 feet beneath the surface. This bed is from 1 to 2 feet thick and rests on pinkish-buff calcareous clay.

In places the lower subsoil layer immediately overlying the chalklike layer is yellow rather than red, but it is nowhere gray. An inclusion of material of different character, not shown separately on the map, consists of very small areas with a bluish-gray subsoil and with the chalklike layer lying at a much greater depth below the surface. Such included areas, which are roughly circular in shape, ranging from 4 to 20 feet in diameter, are commonly known as buffalo wallows. In the virgin sod condition these areas are a few inches below the general ground level and are covered by shallow pools of water for a few days following heavy rains. With cultivation the slight depressions are filled, and the topographic indications of these included areas are no longer evident.

Pullman silty clay loam covers a total area of 101.2 square miles. It is the most extensive agricultural soil in the county. It occurs as a continuous area along the southern edge and throughout the southeastern corner, and a small area near the middle of the northern boundary is a very small part of a large area extending north of Potter County. The large area of this soil extends far beyond the county boundaries to the east, south, and west. Pullman silty clay loam comprises a large proportion of the total area of the High Plains in the Texas Panhandle, both north and south of Canadian River. It occupies about 78 percent of the High Plains section of the county.

The surface relief of Pullman silty clay loam is uniformly smooth and flat or gently sloping. The slope of the land ranges between 0 and 30 inches fall in 100 feet, and probably more than four-fifths of this soil has a slope of less than 10 inches in 100 feet. The main area in this county is bounded along its northern edge by a band of sloping country from one-eighth to one-fourth mile wide, where the soils are shallower. This band of shallower soils lies just above, and slopes down to, the caliche escarpment at the edge of the High Plains. Throughout the area of Pullman silty clay loam are depressions occupied by intermittent lakes which lie from 2 to 50 feet below the general level and in which the run-off water collects, so that the area has no regional drainage but has an internal drainage system. The greater part of the rainfall is absorbed in the soil as it falls, probably less than one-fifth being lost on the native sod. Drainage is slow, which, considering the climate, is advantageous. Terracing the land to prevent loss of water by run-off is probably advantageous.

Pullman silty clay loam is an excellent agricultural soil. Practical farmers consider it the best soil in the county for wheat farming. It is deep, fertile, and smooth, but rather tight and accordingly somewhat droughty.

The type of agriculture, crop adaptations, and prevailing agricultural practices common on farms composed of this soil are generally representative of farms on all the soils of the High Plains areas in Potter County, with the exception of Randall clay. There are some slight differences in productiveness and in the proportion of land in cultivation, and these are brought out in the separate descriptions of the other soils, but otherwise the following discussion is applicable to Pullman silty clay loam, Pullman silty clay loam, shallow phase, Richfield sity clay loam, Richfield clay, Richfield clay, calcareous phase, and Potter clay loam.

Forty-eight thousand five hundred[3] acres of Pullman silty clay loam, of a total of 64,768 acres, or 74.9 percent of the total area of the soil, were in crop land in 1928. Practically the entire acreage of this soil is in farms, little remaining in livestock ranches. That part not in cultivation is used chiefly as farm pastures and homesteads. Additional areas are continually being broken and devoted to crop production, though the amount of this soil remaining in sod is now small. None of the soil in cultivation is being abandoned or allowed to revert to pasture. The soil is very productive and with good rainfall distribution high crop yields are obtained; and even in years of light rainfall, drought-resistant crops, such as the grain sorghums and sorgo, yield some feed.

The important crops grown are winter wheat, the grain sorghums, and sorgo. Corn, oats, barley, spring wheat, broomcorn, Sudan grass, alfalfa, sweetclover, cowpeas, and garden crops are grown on smaller acreages.

Pullman silty clay loam, shallow phase.—Pullman silty clay loam, shallow phase, is known locally as "tight red land of the High Plains." This soil differs from typical Pullman silty clay loam in that it is shallower and all the soil layers are thinner. The red deep subsoil layer, which everywhere underlies the typical soil, occurs close to the surface and is decidedly more red than that beneath the typical soil. It is exposed in roadside cuts and in places is plowed

[3] This figure and all other figures for acreage in cultivation in Potter County, Tex., in 1928 are based on actual delineation and measurement of the various fields which were outlined on the soil-survey field sheets during the progress of the field work

up in fields, thereby giving a red cast or a spotted appearance to cultivated fields. Areas of this soil have somewhat more sloping surface relief than the typical soil. Erosion has prevented the normal development of thick layers of soil, and the soft caliche lies within a depth of 30 inches.

Pullman silty clay loam, shallow phase, consists of a 3-inch layer of dark-brown clay loam or silty clay loam resting on dark reddish-brown rather compact clay. Below a depth of about 12 inches, the subsoil is more friable highly calcareous yellowish-red clay containing some soft aggregates of carbonate of lime. A 10-inch layer of soft caliche occurs beneath a depth ranging from 20 to 30 inches below the surface and grades downward into reddish-buff highly calcareous clay parent material similar to that beneath the typical soil. The topmost surface soil is somewhat hard when dry but rather friable when moist. The upper subsoil layer is hard and compact when dry and plastic when wet. Both surface soil and subsoil, to a depth of 10 or 12 inches, have a neutral reaction and in most places do not effervesce with hydrochloric acid. When moisture conditions are favorable this soil is readily cultivated to a condition of good tilth.

Some areas of this soil were mapped in the rolling areas of the Canadian River Valley, and here the subsoil layers are less red and darker colored than in areas on the High Plains.

This shallow soil is somewhat less productive than the typical soil, and where it occurs associated with the typical soil it is more generally used for the farm pastures. In that part of Potter County southeast of the Chicago, Rock Island & Gulf Railway, 58 percent of the shallow soil and 81 percent of the typical soil are in cultivation. However, in the county as a whole, in 1928, only 4.5 square miles, or 15.8 percent, of the total area of this shallow soil were in cultivation.

The value of all areas of this soil would be enhanced by terracing to minimize erosion and loss of soil moisture. Most of the land has from 24 to 36 inches fall in 100 feet, although one area 2 miles northeast of Amarillo has a slope of only 3 inches in 100 feet

Pullman clay loam.—Pullman clay loam has about the same agricultural value as Pullman silty clay loam. The most important difference between the two soils is that of location, Pullman clay loam being surrounded by other soils of very different characteristics, most of which are entirely unsuited to crop production. The subsoil of this soil is more friable and more easily penetrable than the subsoil of Pullman silty clay loam and therefore absorbs water somewhat more readily. Also the red color in the deep subsoil is generally less pronounced.

Pullman clay loam, to a depth of about 4 inches, consists of dark-brown friable clay loam. It overlies chocolate-brown or reddish-brown moderately friable clay loam or clay, extending to a depth of 24 inches below the surface. The material in these upper two layers is neutral in reaction It is not acid and does not contain free carbonate of lime. Below a depth of about 24 inches the subsoil is brownish-red or reddish-yellow calcareous friable clay loam or clay, which, at a depth ranging from 3 to 5 feet, rests on highly calcareous soft almost white material, or soft caliche.

Pullman clay loam has a total area of 66.5 square miles. In 1928, only 1.3 square miles, or 2.0 percent of the total area, were in cultivation. This soil occurs in somewhat flat or gently sloping areas within the rolling areas of Canadian River Valley, most of it lying between Amarillo and Canadian River. Several fair-sized areas are in the north-central and northeastern parts of the county.

Only about 850 acres of this soil were cultivated in 1928. It is used for the production of feedstuffs, such as milo, kafir, and sorgo. It is well suited to cultivation, but much of it occurs in small areas surrounded by soils of low agricultural value. Some areas, however, are associated with other good agricultural soils. The land can probably be utilized to advantage for the production of supplemental feed for the livestock which are grazed on the surrounding rough country.

The natural vegetation on this soil consists largely of buffalo grass and blue grama, with a moderate growth of scrubby mesquite brush, and a sparse growth of a woolly loco, needlegrasses, other grasses, and coarse plants.

Pullman clay loam lies mostly within large ranches, in association with large areas of nonagricultural land, and in general it has no separate selling value. It has about the same grazing value for cattle and other livestock as Pullman silty clay loam.

Richfield silty clay loam.—Richfield silty clay loam consists of dark-brown noncalcareous silty clay loam to a depth of about 10 inches. This layer is underlain by dark chocolate-brown or very dark chocolate-brown heavy noncalcareous clay. Below a depth of about 20 inches the subsoil is calcareous and brown, gradually becoming lighter colored with increase in depth. It grades below into gray calcareous clay at a depth of about 5 feet beneath the surface. This soil occurs in very small areas, and its total acreage is small.

Richfield clay.—The 4-inch surface layer of Richfield clay consists of nearly black noncalcareous clay grading below into dark chocolate-brown noncalcareous clay which, at a depth of about 20 inches, is calcareous and lighter in color. From a depth of about 20 inches to a depth of about 60 inches, the subsoil is brown calcareous clay which grades below into gray calcareous clay containing a few lumps of soft carbonate of lime. The heavy character of the topsoil causes intractability, and cultivation is difficult.

Richfield clay, calcareous phase.—Richfield clay, calcareous phase, consists of dark-gray heavy calcareous clay to a depth ranging from 2 to 3 feet. The immediate surface soil is somewhat darker than the material beneath. The material gradually becomes lighter colored with increase in depth and below a depth of 3 feet is gray or light-gray calcareous clay. Below a depth of 42 inches the clay grades into gray or grayish-white calcareous clay containing a large quantity of limy concretions and soft white chalky lumps of calcium carbonate.

Fritch silty clay loam.—Fritch silty clay loam is a heavy-textured soil occurring as flat areas within the Canadian River Valley in the northeastern part of the county. It has apparently about the same agricultural value and adaptations as Pullman silty clay loam. Its total area is only 64 acres, none of which is in cultivation. This soil differs from Pullman silty clay loam chiefly in that it is underlain by very heavy and intractable very dark colored material at a depth of about 3 feet below the surface. It is developed on smooth surfaces having but a slight degree of slope. The upper subsoil layer is not quite so heavy as that of Pullman silty clay loam, and there is less red color in the subsoil.

Fritch silty clay loam consists of a 4-inch layer of dark-brown friable silty clay loam or silt loam over brown moderately compact light clay which, at a depth of about 24 inches, grades below into very dark brown or black very plastic and compact clay. Below a depth of about 40 inches this material grades into reddish-brown sandy loam which is highly calcareous below a depth ranging from 8 to 10 feet.

The dominant natural vegetation is buffalo grass and blue grama, with a scattered growth of low mesquite brush.

Zita clay loam.—Zita clay loam is an excellent agricultural soil. Most of the land is somewhat sloping, but the soil is deep and productive. It is suited to about the same crops, and cultural practices are about the same as on Pullman silty clay loam As it occurs in comparatively small areas, it is less suited to large-scale wheat farming than the Pullman soil.

The topsoil consists of dark-brown or dark chocolate-brown calcareous friable granular clay loam about 18 inches thick. It grades into reddish-brown or brown friable calcareous clay loam which, at a depth ranging from 36 to 50 inches, grades into impure soft pinkish-white carbonate of lime. This soil differs from Pullman silty clay loam in that it is calcareous from the surface down and has a more friable subsoil. Owing to its more friable character, it is somewhat more drought resistant than that soil. Yields are about the same as, or slightly higher than, on the Pullman soil.

Zita clay loam occupies a total area of 14.3 square miles. It occurs as colluvial benches in the Canadian River Valley rolling lands. The largest area is southwest of Gentry. Owing to its mode of occurrence, only a small proportion of the land is cultivated. It supports a heavy growth of grama and buffalo grass, with less quantities of needlegrasses, mesquite brush, and other plants, most of which afford good range forage.

Spur clay loam.—Spur clay loam is a chocolate-brown friable calcareous clay loam, the topsoil and subsoil differing but little In places thin layers of sandy material occur throughout the subsoil. This is a deep productive soil The areas in the vicinity of Cliffside are rather large, but many smaller bodies occur in other sections. Most of this soil near Cliffside is cultivated, and feed crops are grown chiefly. Small areas under irrigation produce garden and fruit crops It is bottom land subject to overflow.

Spur fine sandy loam.—Spur fine sandy loam is similar to, but sandier than, Spur clay loam. It consists of calcareous mellow chocolate-brown fine sandy loam to a depth of several feet. This is a drought-resistant and very productive soil. It occupies narrow strips along small streams tributary to Canadian River in the southern part of the county. The areas in cultivation are located mainly at Word ranch and near Cliffside and Pleasant Valley. The common feed crops are grown, and small areas are used for growing garden and fruit crops under irrigation.

Miller clay loam.—Miller clay loam consists of friable calcareous chocolate-red clay loam several feet thick. The subsoil, in places, is heavier in texture than the topsoil.

This soil occurs as bottom-land strips bordering or near Canadian River. Most of it is either next to the bluffs which line the river valley or at the entrance of the larger tributary streams.

The soil in some of the lower lying positions contains a rather large amount of alkali (water-soluble salts). Much of this same kind of soil lies in the valley just west of Potter County and is farmed under irrigation.

Miller clay loam, colluvial phase.—Miller clay loam, colluvial phase, is red calcareous friable clay loam several feet thick. It differs from the typical soil in surface relief and occurrence. It occupies gently sloping fans at the bases of steep slopes and cliffs. It is somewhat gullied, and it contains a few stone fragments. Owing to rapid drainage and a surface cut by erosion, the land is not well suited to cultivation. It is utilized exclusively as grazing land, for which purpose it is excellent, as it supports a heavy growth of grasses.

Yahola fine sandy loam.—Yahola fine sandy loam consists of red or light-red calcareous mellow fine sandy loam underlain by thin sandy layers variously placed beneath the topsoil down to a depth of several feet. This is a productive soil but probably less so than Spur fine sandy loam. It is suited to the production of many kinds of crops. It occurs along Canadian River, in bottoms which are subject to occasional overflow. Alkali (water-soluble salts) is present in moderate amounts, but in most places the amount is not sufficient to be harmful to farm crops. Because of the occurrence of this soil in accessible localities surrounded by nonagricultural land, it is utilized as grazing land and is excellent for that purpose. In a few areas the native grasses are cut for hay.

Yahola loamy fine sand.—Yahola loamy fine sand consists of loose yellowish-red or light-red loamy fine sand to a depth of several feet. It is similar to, but sandier than, Yahola fine sandy loam. The surface soil is so loose that it blows easily, and cultivation of the land is not generally feasible. One field of about 100 acres in the northeastern part of the county was at one time in cultivation, but it has been turned back into grassland. The soil furnishes excellent grazing, and the best utilization for most of it is as pasture land or as native meadow for hay. It occurs in bottoms along Canadian River.

MODERATELY PRODUCTIVE AGRICULTURAL SOILS, SANDY IN TEXTURE

Amarillo fine sandy loam.—Amarillo fine sandy loam is the soil known locally as "red sandy land." In Potter County this soil occurs only on rather smooth areas within the Canadian River Valley rolling lands, though in some other counties it occurs on the High Plains.

The chief differences between this soil and Pullman silty clay loam are that the Amarillo soil is sandier, more friable, more red in color, and dark colored to less depth. It also has a more rolling surface relief and occurs as smaller irregular areas which include many patches of shallow soils. The practical significance of these differences is that this soil has a greater tendency to blow and is therefore less suited for the production of wheat or other small grains; it is more drought resistant, being more easily permeated by rain water; it is less subject to erosion and loss of water as run-off; and the surface relief and extent do not allow large-scale farm operations. On the other hand this soil is easily worked throughout a wide range of moisture conditions and is well suited to the production of certain market-garden and fruit crops, which prefer rather loose open-textured soils. The soil has a lower agricultural value than the large smooth areas of heavier soils. It is used as grazing land in large ranches, and near Amarillo a few areas have been intensively developed for home gardens and fruits.

The 12- to 16-inch topsoil of Amarillo fine sandy loam is friable granular dark reddish-brown fine sandy loam. The subsoil, to a depth ranging from 24 to 36 inches, is dark brownish-red friable loam or fine sandy clay loam, grading into yellowish-red or light-red highly calcareous loam or heavy fine sandy loam, which contains a few soft carbonate of lime concretions. At a depth ranging from 3 to 8 feet, this material passes rather abruptly into soft chalky yellowish-white impure carbonate of lime. The chalklike layer is commonly 10 or 12 inches thick and grades downward into a less highly calcareous light-red sandy deposit, the parent material.

The immediate surface layer, which is 2 or 3 inches thick, is rather loose and incoherent loamy fine sand or light fine sandy loam. Below this loose layer the topsoil has a very well defined friable large columnar or blocklike structure when dry, which is very noticeable in road cuts The material is hard when dry, but it is friable when moist and works easily into a state of good tilth. All layers are readily permeable by water, enabling ready absorption of rain water which is stored in the heavier layers beneath, thus causing very good drought resistance. Both the topsoil and upper part of the subsoil, to a depth of about 24 inches, are neutral in reaction, and the soil materials do not effervesce with hydrochloric acid, indicating that they contain no free carbonates. Below this depth the subsoil is calcareous.

Mapped areas include variations in the texture of the surface soil and in the thickness of the different soil layers. The soil occurs in small areas and is more sloping and shallower in places than in some other counties.

Amarillo fine sandy loam comprises a total area of 48.5 square miles. It is the most important agricultural sandy soil occurring within the Canadian River Valley rolling lands. It occurs commonly on gently sloping or moderately sloping stream divides, adjacent to steeper, shallower, and eroded soils of the Potter series.

Approximately 2 1 square miles of this soil were in crop land in 1928. Most of the cultivated land is in the vicinity of the Pleasant Valley community a few miles north of Amarillo. Farming on this and associated sandy soils consists largely of the production of grain sorghums, sorgo, and other feedstuffs, grown as feed for dairy cattle, hogs, chickens, or other livestock. Cultural practices do not differ from those in general use, except that blowing of loose soil is retarded by leaving the ground in a very rough condition when not protected by growing plants. Farmers report that yields of grain sorghums and other row crops are fully as good on this soil as on Pullman silty clay loam. Acre yields of grain sorghums range from 10 to 75 bushels of grain and average between 25 and 30 bushels, and sorgo yields from 2 to 10 tons of air-dry forage. Sudan grass and alfalfa are grown on small acreages.

A considerable proportion of this soil utilized for crop production is planted to small gardens and fruit orchards containing a wide variety of vegetables and fruits. With proper care practically all vegetables can be grown with success, and cherries are reported to be very successful. The gardens and orchards are given some irrigation from water supplied by wells. The quality of the water is good, and no trouble has been experienced with alkali (soluble salts). In many localities water is available in wells at a depth of less than 100 feet.

Most of this soil is considered good grazing land and is used for that purpose, but larger areas will probably be gradually placed in cultivation. The soil occurs in rather small bodies surrounded by areas of shallow soils not well suited to farming. The natural vegetation consists largely of bunch grasses, with a small amount of short grass. Sage grass probably constitutes one-half the total vegetation. Other prominent plants include needlegrass, blue grama, black grama, yucca, sawbriar, ragweed, and rosinweed.

Drainage is thorough, both from the surface and beneath. Any soil in this section, which has sufficient slope to allow water to run off, is excessively drained and is eroded to some extent. Therefore this and all other soils, if terraced properly, will probably respond with increased yields, though the structure of this soil is such that erosion and run-off are less severe than on the heavier soils. The few terraces have not been well constructed or maintained.

Fritch fine sandy loam.—Fritch fine sandy loam is locally known as "black sandy land." It is a flat deep soil, very productive, and suited to the same crops as is Amarillo fine sandy loam, and crop yields probably range somewhat higher than on that soil. It differs from Amarillo fine sandy loam in that it is somewhat darker, more nearly flat, and has a very dark colored heavy layer at a depth of about 3 feet.

The topsoil is dark-brown friable fine sandy loam about 18 inches thick. It grades below into brown calcareous fine sandy loam which, at a depth of about 30 inches, grades into very dark brown or black clay. The clay is very plastic when wet and extremely compact when dry. This material changes, at a depth of about 40 inches, to reddish-brown calcareous fine sandy loam which extends to a depth of about 100 inches, where it grades into highly calcareous material.

This is not an extensive soil, only 7.9 square miles being mapped. It occurs as smooth areas within the Canadian River Valley rolling lands, associated with Amarillo fine sandy loam. In 1928 a total of 65 acres was in cultivated crops.

In some sections, farmers consider this their best land, and crop yields are reported to be very good. The general agricultural relationships of this soil coincide with those of Amarillo fine sandy loam.

The natural vegetation consists largely of blue grama and buffalo grass, with some winterfat, needlegrasses, and a few other plants, but in general no sage grass grows on this soil.

HEAVY, MODERATELY GOOD AGRICULTURAL SOILS

Potter clay loam.—Potter clay loam differs from Pullman silty clay loam in that it is much shallower, more sloping, lighter colored, without any red layers, highly calcareous, and looser. This is the shallowest soil of the High Plains in Potter County To a depth ranging from 10 to 20 inches it consists of highly calcareous granular yellowish-brown heavy clay loam or clay, resting on a layer, ranging from 2 to 10 inches in thickness, of friable clay containing a very high percentage of carbonate of lime. The color of the second layer is brownish yellow, with many white spots where the carbonate has separated and concentrated into small nodules or concretions. Below the second highly calcareous layer, the underlying material, to a depth of many feet, is pinkish-buff highly calcareous clay practically identical in character with the parent material which underlies Pullman silty clay loam at a great depth.

The surface soil is moderately plastic and slightly sticky when wet, crumbly when moist, and moderately hard when dry. In cultivated fields the material crumbles to a loose granular or pelletlike condition and has considerable tendency to blow.

Potter clay loam covers a total area of 41.3 square miles, of which only 2.1 square miles are in crop land. This soil occurs as the most sloping areas on the High Plains and as moderately sloping areas within the Canadian River Valley rolling lands. It is locally known as "chalky land." The most extensive bodies form a broken band of sloping soil between the higher and flatter Pullman silty clay loam areas and the caliche escarpment at the edge of the High Plains. The soil also occurs as narrow rims around many of the lake beds of the High Plains. Potter clay loam constitutes 1.8 percent of the typical High Plains section of the county. In the southeastern part of the county, 17 percent of the soil is in cultivation.

Potter clay loam is recognized by farmers as being less valuable for crops than Pullman silty clay loam, and, as it occurs to a large extent in association with that soil, most of it is utilized for pasture. The percentage of Pullman silty clay loam in crop land is four times as great as that of Potter clay loam. This soil is too sloping, shallow, loose, and subject to blowing for a first-class farming soil. Some farmers report that it produces nearly as high yields as Pullman silty clay loam when it is first placed in cultivation, but a material decrease is noted after 5 years of use for crops. However, the potential fertility of this shallow soil seems to be fairly high, and, as the amount of fertility removed by a wheat crop is not great, it is possible that the rapid decrease in yields is owing primarily to erosion by wind and water rather than to removal of plant food by growing crops. Farmers state that after a few years of cultivation much of this soil blows away. Visible evidences of the ravages of erosion are the gullies which extend into bodies of this soil.

All this soil in crop land should be terraced, in order to conserve moisture and prevent erosion, but it seems best practice to use the land for pasture. The slope over most areas ranges from 2½ to 6 feet fall in 100 feet, and experiments have conclusively shown that unprotected land of this character is subject to severe erosion.

Where farmed, the methods and practices employed are much the same as on Pullman silty clay loam. Results have shown that continual growing of small grains causes conditions more favorable for soil blowing than where some other crops are grown.

In the virgin state this soil is easily recognized by the type of plants growing on it. The natural vegetation on Pullman silty clay loam is a very nearly pure stand of short grasses, but on Potter clay loam it consists chiefly of short grasses in association with needlegrasses, whitetop, sage grass, locoweed, and various legumes. In areas where the soil is very shallow, the surface is covered with a thick growth of sage grass. The grazing value of this soil is almost as good as that of Pullman silty clay loam.

Weymouth clay loam.—Weymouth clay loam is a moderately sloping shallow heavy soil occurring within some sections of the Canadian River Valley rolling lands. It is similar to Potter clay loam but is generally more red in color, because it has developed from red parent materials.

The 8- to 12-inch surface soil is friable granular reddish-brown clay loam which, in most places, is sufficiently calcareous to effervesce with hydrochloric acid. The subsoil is reddish-brown highly calcareous clay or clay loam, which, at a depth ranging from 15 to 30 inches, rests on a 4- to 8-inch layer of soft pinkish-white carbonate of lime. This thin layer in turn rests on shales and clays in which a red color is prominent. These comprise the parent material from which the soil has developed.

Weymouth clay loam occupies a total area of 44.8 square miles. It occurs in moderately sloping areas in localities where Triassic or Permian "Red Beds" are exposed. The largest areas are in the central and southwestern parts of the county.

The natural vegetation consists mainly of sage grass, black grama, blue grama, needlegrasses, catclaw, and various other plants. The land is considered good grazing land and is used almost exclusively for that purpose. One small field in cultivation in 1929 produced moderate yields of grain sorghums. Cultivated fields should be terraced in order to conserve soil moisture and to prevent erosion.

SANDY, POOR AGRICULTURAL SOILS

Potter fine sandy loam.—Potter fine sandy loam is shallow chalky land, by some called "white sandy land" or "chalky sandy land". It occurs in extensive areas within the Canadian River Valley rolling areas. The land is more sloping and eroded than Amarillo fine sandy loam. Farmers generally avoid cultivating it, as it is considered very poor land. Where cultivated, crop yields are very low, and in places the plants turn yellow and die, probably owing to chlorosis. This soil is very shallow, highly calcareous, and contains no red-colored layer in the profile. It is generally unsuited to farm crops.

The topsoil of Potter fine sandy loam consists of brown or grayish-brown highly calcareous granular mellow fine sandy loam from 10 to 24 inches thick. This material rests on a bed of impure yellowish-white carbonate of lime, ranging from 3 to 12 inches in thickness, which, in turn, is underlain by reddish-buff calcareous fine sandy loam. Mapped areas of this soil include small bodies of some other soils, especially of Amarillo fine sandy loam, shallow phase. In many places the soil is so shallow that the underlying soft caliche is turned up in plowed fields.

A total area of 93.3 square miles of Potter fine sandy loam occurs in Potter County. There are large areas throughout the rolling lands of the Canadian Valley, both north and south of the river. Broken areas occur in a band at the base of the caliche cliffs which mark the outer border of the High Plains. The soil also occupies the moderately sandy parts of the rolling lands, where erosion does not allow the development of Amarillo fine sandy loam. The surface relief is gently or steeply rolling, and the excessive drainage causes rapid erosion.

Small areas of this soil, most of them in the vicinity of River Road School and Pleasant Valley School a few miles north of Amarillo, are cultivated in association with larger areas of deeper soils. Approximately 384 acres were in cultivation in 1929. Crop yields are somewhat less than on Amarillo fine sandy loam.

Most of Potter fine sandy loam is used for grazing livestock. The natural vegetation is characterized by a heavy growth of sage grass and small amounts of blue grama, black grama, needle grasses, purple loco, catclaw, and numerous other plants. This type of vegetation offers good grazing and will support from 25 to 40 head of cattle a square mile during normal seasons.

Amarillo fine sandy loam, shallow phase.—Amarillo fine sandy loam, shallow phase, differs from typical Amarillo fine sandy loam in that the different soil layers contain less dark and more red material, are thinner, and the underlying soft caliche layer lies at a depth of less than 30 inches below the surface. As mapped, many small areas of the typical soil are included within areas of the shallower soil.

This soil covers a total area of 14.4 square miles, of which only about 65 acres were in cultivation in 1928.

Land of this phase is used for the same purposes as typical Amarillo fine sandy loam, though a smaller proportion is in cultivation, and crop yields are reported to be lower. It may be considered of doubtful value for cropping purposes.

The natural vegetation is characterized by a growth of catclaw which does not grow on typical Amarillo fine sandy loam, short grasses are less abundant, and sage grass is more abundant.

Enterprise loamy fine sand.—Enterprise loamy fine sand differs from Amarillo fine sandy loam in being looser and more sandy. It blows so badly in winds that its use for farm crops is greatly restricted. It consists of reddish-brown loose noncalcareous loamy fine sand, about 12 inches thick, overlying yellowish-red noncalcareous loamy fine sand extending to a depth of about 30 inches, where the material rests on yellowish-red calcareous fine sandy loam. This material, in turn, at a depth ranging from 4 to 5 feet, rests on a layer of yellowish-white sandy soft impure carbonate of lime.

Much of this soil has been subjected to erosion, and in places the layers are thin and the parent material lies near the surface.

The total area of Enterprise loamy fine sand in Potter County is 9.2 square miles. The soil occurs in small bodies in the eastern part of the county. It is all used as pasture land, and such use will probably continue indefinitely.

NONAGRICULTURAL LAND

Rough broken land.—Rough broken land is a term used to designate a topographic rather than a soil condition. Areas too rough for tillage and not suited to any other purpose than grazing are shown on the soil map as rough broken land. In such areas the soils are not well developed, and soil characteristics are for the most part absent. The surface soil material consists essentially of unweathered or only slightly changed geologic material rather than soil.

Several phases of rough broken land, none of which is differentiated on the map, occur in this county. They are all within the rolling valley of Canadian River, locally known as the Canadian River breaks. The surface of the land included within this division is rough and severely dissected.

In places large areas of sandy and gravelly beds are exposed and through erosion have been reduced to steep slopes, some of which are stony, gravelly, and deeply cut into gullies and bare eroded spots. In other places, the "Red Beds" have been exposed and eroded into hills and steep slopes, into which erosion has cut many deep ravines and gullies, and in places outcropping stony formations comprise small areas of rough stony land. On "Red-Beds" areas the surface material is largely of clay or clay loam texture. Narrow belts of outcropping caliche constitute blufflike escarpments, where the caliche has been hardened by exposure to a rocklike structure, resembling slopes and cliffs of limestone. These areas, locally known as "caliche breaks", are almost bare of vegetation. They lie near the border of the High Plains and give rise to the common term cap rock.

In some sections of the rolling country, fair-sized bodies of moderately rough land consist of deep beds of rounded gravel, on which rests a very thin layer of gravel and fine earth with the texture of gravelly fine sandy loam. These hilly areas, which are cut by many gullies, are included with rough broken land. Also included with this land are small bodies of comparatively smooth land, where the very thin topsoil covering rests on hard caliche, fragments of which are strewn over the surface.

Rough broken land is used agriculturally only for grazing. The beds of gravel constitute a source of good building material, and the gravel is used for various other purposes, including road building.

The growth of natural vegetation is scant on many of the slopes of rough broken land, though included slight depressions and valleys support an abundant growth of nutritious grasses. The principal grasses include sage grass, several species of grama, and needlegrass, and some buffalo grass grows in specially favored spots of heavy soil. The shrubs thinly scattered over the land are mainly yucca, mesquite, catclaw, juniper, and sumac. Herbaceous plants are abundant and include sand sage brush, locoweed, rosinweed, and others.

Owing to the shelter afforded by the rough land and to the natural supply of water in springs and stream courses, this land is favored for cattle ranching. It is stated that on one ranch comprising 160.000 acres, one-half of which is rough stony land, 16,000 head of cattle were carried for many years.

Potter gravelly loam.—Potter gravelly loam consists of a 3- or 4-inch layer of light-brown or gray calcareous loam resting on hard caliche. This soil occupies smooth gentle slopes just below the caliche breaks in the rolling lands of Canadian River Valley. It occurs in very small patches and supports a very scant vegetation. It is unimportant in extent and in grazing value. The largest bodies are northwest of Amarillo in the southern part of the county.

Weymouth clay loam, eroded phase.—Weymouth clay loam, eroded phase, consists of raw or slightly weathered red slightly calcareous sandy clay and shale. In places, a surface layer of reddish-brown calcareous clay loam, a few inches thick, overlies an imperfectly developed soft caliche layer.

This soil supports little vegetation, though small quantities of grasses and shrubs grow in places. It occupies eroded slopes which are not sufficiently rough to be classified as rough broken land and also includes a few areas which, with terracing, might possibly be farmed.

Randall clay.—Randall clay is the soil occupying the lake beds which occur on the High Plains. It consists of heavy compact and intractable gray or bluish-gray clay extending downward for several feet with little change other than some decrease in the dark color and some increase in yellowish-brown or rust-brown mottlings with depth. In most places the soil is noncalcareous to a depth of about 24 inches, but below this depth it is calcareous. On drying, the immediate surface soil crumbles to a somewhat granular condition, and cracks several inches wide and several feet deep form.

Randall clay is not suited to crop production in its present condition. Most of the areas are covered with water for a considerable period every year, and artificial drainage of most of the land is not practical. Prevention of run-off from the surrounding territory might possibly serve to keep out the excess water. The soil is very heavy and would be difficult to cultivate. Areas of this soil have been cultivated in places outside the county and proved to be moderately productive, but the soil seems to have little drought resistance.

Randall clay is inextensive. It constitutes approximately 3 percent of the High Plains part of Potter County, where it is associated with Pullman silty clay loam. Only two small areas are within the Canadian River Valley rolling land, one along Pedrosa Creek, southwest of Blackburn Camp, and the other along the railway north of Marsh. This soil is utilized as pasture land, and no attempt has been made to cultivate any of the larger bodies. Some of the land is entirely bare of vegetation, and in other places it supports a good growth of native plants which afford fair grazing. A few small areas are cultivated in association with fields of Pullman silty clay loam, but crop yields are usually poor.

Enterprise fine sand, dune phase.—Enterprise fine sand, dune phase, consists essentially of dune sand having a covering of vegetation. It consists of loose reddish-yellow noncalcareous fine sand to a depth of several feet. Commonly the topmost part of the soil, to a depth ranging from 4 to 8 inches, is slightly darkened to a brown color by the accumulation of organic matter.

This soil has been subjected to wind action which has caused a characteristic dunelike configuration, though the dunes are rather low and stationary. The largest bodies occur in the valleys of Sand, Corral, Lahey, John Ray, and Pitcher Creeks, in the northern part of the county, and along Bonita and Coetas Creeks, in the eastern part.

The natural vegetation consists of a type of plants commonly found on loose sandy soils. The grasses are tall, coarse, and tend to grow in bunches rather than to form a sod. Among the most common plants growing on this soil are sage grass, big bluestem, Indian grass, sandgrass, switch grass, sand sagebrush, ill-scented sumac, wild plum, needlegrass, black grama, blue grama, yucca, wormwood, sawbriar, and ragweed. The ranchers consider this vegetation valuable for winter pasture. The coarse bunch grasses are less palatable and not so nutritious to livestock as the grama grasses and buffalo grass, but they are more valuable to the cattle when the ground is covered with snow.

Dune sand.—Areas of wind-drifted sand in dunes which are largely bare of vegetation are mapped as dune sand. Areas of sand which are covered with sufficient vegetation to offer some grazing and to check active blowing are mapped as Enterprise fine sand, dune phase.

Dune sand in the Canadian River flood plain consists of calcareous yellowish-gray sand which has been drifted into dunes by wind action. It occurs chiefly adjacent to river wash, the shifting river-bed sand, which is exposed at low-water stage, and which blows out on the low alluvial bench and drifts into dunes of loose fine sand. The vegetation is scant, consisting of coarse grasses and weeds not highly nutritious or palatable to livestock. The sand from some areas of dune sand drifts over areas of good land and depreciates their value.

Dune sand covers a total area of 4.6 square miles. The largest body lies between Chicken and Bonita Creeks in the eastern part of the county, and small areas occur on the flood plain of Canadian River.

Dune sand has no value for general crop production and very little or no value for grazing land.

River wash.—River wash consists of the bare constantly shifting sand deposits which fill the channels of Canadian River (pl. 2, *A*) and some of the larger tributary streams. The material consists of loose calcareous yellowish-gray fine sand and sand, with here and there pockets of darker colored silt and clay. River wash is many feet thick in the bed of Canadian River. In places it contains considerable alkali (water-soluble salts).

During flood stages of the stream, areas of river wash are covered by several feet of swiftly moving water, and when the material is dry, especially immediately after floods, there are many spots of treacherous quicksands.

River wash has no agricultural value. It furnishes no grazing, and in most places it is fenced off, in order to prevent cattle from miring in the quicksands. During high winds the sand drifts badly and in places drifts into dunes which cover areas of alluvial soils.

River wash covers a total area of 18.6 square miles. On a few of the higher spots a sparse growth of willow, Carrizo, saltgrass, and a few other plants have obtained a foothold.

SOILS AND THEIR RELATIONSHIPS

Potter County is located within the region where well-developed soils are everywhere underlain by a layer of carbonate concentration consisting principally of calcium carbonate. All the soils have developed under a grass vegetation. The normal regional soil profile is characterized by granular dark reddish-brown or very dark brown surface soils underlain by friable brownish-red or brown subsoils which underlie a layer of carbonate concentration. This normal profile is exhibited by the Amarillo and Zita soils, the Amarillo being dark reddish-brown soils and the Zita, very dark brown. The compact Pullman profile, which is dominant in smooth well-drained areas in Potter County, is interpreted as being a somewhat abnormal type of soil development, presumably because of the presence of small quantities of sodium salts in the parent material.

The Amarillo soils constitute the dark reddish-brown granular normal soils developed on the High Plains. They are inextensive in Potter County. They are largely of medium sand and sandy texture. They occupy smooth undulating well-drained areas.

A typical profile of Amarillo fine sandy loam located 4 miles north of Amarillo, 500 feet east of the southwest corner of section 161, block 2, A. B. and M., is as follows:

From 0 to 6 inches, dark reddish-brown granular noncalcareous fine sandy loam. The topmost inch consists of loose loamy fine sand. The material is friable and changes gradually to the material below.

From 6 to 24 inches, reddish-brown granular noncalcareous fine sandy clay loam The color grades to brownish red in the lower part of the layer. The material is friable and aggregated into somewhat round granules, about one-eighth inch in diameter, the exteriors of which are dull and darker than the interiors. The well-defined columnar structure extends from the base of this layer to within 1 inch of the surface of the soil. The columns are rectangular, vertical, smooth faced, from 3 to 6 inches in diameter, and from 18 to 24 inches long They have no horizontal faces, they are friable and have no varnishlike coatings, and they are aggregates of granules. Worm casts are abundant, and plant roots permeate throughout the soil mass. The change to the next lower layer is gradual

From 24 to 80 inches, dull-red calcareous friable heavy fine sandy loam grading to more highly calcareous yellowish-red friable fine sandy loam in the lower part. This layer is permeated by a network of fine threadlike channels which in the upper part are open but in the lower part are filled with white material which appears to be calcium carbonate The change to the underlying layer is abrupt.

From 80 to 94 inches, the layer of carbonate concentration. Nonindurated very highly calcareous yellowish-white fine sandy loam with streaks and bands of white almost pure calcium carbonate. The material in this layer is tubular or permeated with a network of fine channels similar to those in the overlying layer The transition to the parent material is indefinite.

From 94 to 100 inches, the parent material. Highly calcareous reddish-buff friable fine sandy loam containing a few aggregations of soft white calcium carbonate.

The Zita soils are very dark brown or black friable granular normal soils developed on the High Plains. They occupy smooth well-drained areas, and they are most typically heavy textured, especially in localities where the parent materials carry a high content of calcium carbonate. The areas mapped occur on colluvial fans and do not show complete typical development, as they do in Randall County. The Zita soils are dark nonred equivalents of the Amarillo soils. They differ from the Pullman soils in their granular more friable character and in the absence of a noncalcareous yellowish-red deep subsoil layer.

Pullman silty clay loam is the dominant well-developed soil occurring in Potter County. A typical profile (representing the soils of the Pullman series) exposed in a recent cut along the Chicago, Rock Island & Gulf Railway, 1 mile northeast of Masterson and about 14 miles northeast of Amarillo (pl. 2, *B*), is as follows:

From 0 to 5 inches, silty clay loam which is very dark brown when moist and dark grayish brown when dry. There is no effervescence with hydrochloric acid. The pH value is 6.5 The material has a slight horizontal arrangement but no well-defined platiness or lamination It is slightly hard when dry, friable when moist, and slightly plastic when wet This layer grades through a very thin transitional layer to the one below

From 5 to 24 inches, clay which is dark chocolate brown when wet and chocolate brown when dry. There is no effervescence with hydrochloric acid. The pH value is 7 8 Following frosts or while moist following rains, the exposed surfaces of this layer assume a very fine granular condition However, the unexposed material, regardless of moisture condition, shows little granulation When dry the material in this layer contracts into irregular very hard blocks, 2 or 3 inches in diameter, with uneven faces and a roughly cubical shape. The surfaces of these blocks are slick, or varnishlike, and they have characteristic bumpy or granular surfaces, indicating a slight development of a granular structure. The material is very hard when dry, very compact when moist, and very plastic and moderately sticky when wet Worm casts are absent, and plant rootlets largely follow the crevices between structure fragments.

From 24 to 48 inches, calcareous clay containing a very few small soft carbonate of lime concretions The color is chocolate brown or dark reddish brown, the red increasing with depth and merging with the color of the layer below. The pH value is 7 8 The division between this and the overlying layer is placed at the depth of reaction with hydrochloric acid The clay is very hard when dry, very compact when moist, very plastic and moderately sticky when wet, and extremely tough when nearly dry No well-defined structure or breakage is evident

From 48 to 68 inches, noncalcareous clay with a very few fine soft carbonate of lime concretions The material is reddish yellow or dull red when moist and brownish red when dry. The pH value is 7 9 The material is moderately hard when dry, moderately compact when moist, and moderately plastic when wet. When dry it breaks into irregular clods about one-half inch in diameter In some places in the lower 4 inches of this layer, there is also a faint dark-colored film on the outsides of the small clods, apparently consisting of organic matter The material in the lower part of this layer is somewhat tubular, similar to that in the layer below The change from this layer to the one below is abrupt

From 68 to 84 inches, the layer of carbonate concentration Approximately 60 percent of the volume consists of roughly spherical aggregations of lime carbonate ranging from one-half inch to 1½ inches in diameter These concretions are yellowish white or creamy white, whereas the rest of the material is light-brown or reddish-buff highly calcareous clay The pH value is 7 9 The material in this layer is slightly hard when dry, friable when moist, and slightly plastic and slightly sticky when wet. The whole layer is filled with a network of open fine tubular channels about one one-hundredth inch in diameter and of undetermined length The change to the underlying parent material is gradual The heaviest concentration of carbonate of lime lies between depths of 68 and 74 inches No gypsum is apparent in this layer, and no induration has taken place

From 84 to 132 inches +, the parent material of light-brown or reddish-buff highly calcareous clay which is friable when moist and slightly hard when dry The pH value is 8 3 About 15 percent of the volume consists of small soft white lime-carbonate aggregations about one-half inch in diameter There seem to be pockets and layers of higher lime-carbonate content Except for the variation in carbonate concentration, the material in this layer is very uniform.

The profile described is on the High Plains, about 3 miles southeast of the Canadian River breaks, where the elevation is approximately 3,550 feet above sea level. In this location the surface of the ground has a slope of 1½ inches in 100 feet. The point at which the profile was examined is 500 feet above a sharper slope occupied by Pullman silty clay loam, shallow phase. The location is representative of this soil type. The total depth of the soil and the thickness of the different soil layers is somewhat greater than the average.

Variations in different areas of this soil are very slight, the chief variation being that of depth and thickness of the different soil layers. Thirty-nine measurements to the top of the layer of carbonate accumulation in typical areas of this soil gave an average depth of 55 inches, with an average deviation of 5.5 inches, a minimum depth of 36 inches, and a maximum depth of 72 inches.

There is also some variation in the relationship between the depth of the top of the distinctly red material and the presence of free lime, as evidenced by reaction with hydrochloric acid. Although the normal order of change is as given in the profile described, the third layer (from 24 to 48 inches) is somewhat thicker than usual. In the shallow phase of Pullman silty clay loam, the order of change is reversed, and the depth below the surface at which the subsoil becomes red is less than the depth at which it becomes calcareous. Where the total depth to the top of the layer of carbonate concentration is about 36 inches, the depths of these two changes coincide; where it is greater the order is given in the described profile; and where it is less the order of change is reversed and the transitional layer, corresponding to the third layer (24 to 48 inches) of the profile described, is red and contains no free carbonates. As will be brought out later, the order of change of these two characteristics in Amarillo fine sandy loam is also reversed from the normal order of change in Pullman silty clay loam and corresponds to the order of change in Pullman silty clay loam, shallow phase.

Another variation which was found in about one-twentieth of all the deep borings made in Pullman silty clay loam, and which may be seen in a few places in the railway cut already described, is the presence of a very thin, very dark colored layer between the red deep subsoil layer and the layer of heavy carbonate concentration. This layer ranges from one-half inch to 1½ inches in thickness and consists of very dark brown or black clay containing from one-fourth to one-third of its total bulk of soft white calcareous aggregations. The occurrence of this variation was so infrequent that no significance would have been placed on it, other than it might have been an old prairie-dog hole, had it not been for the occurrence within the county of a series of soils (the Fritch) having a well-developed very dark colored layer about 3 feet below the surface.

Very small inclusions of a different soil occur beneath slight depressions which, in a virgin condition, were covered with water for a few days following rains. The soil in these inclusions has a bluish-gray subsoil and a deeper lying layer of carbonate concentration (possibly in some places the layer of concentration is entirely absent) and serves to illustrate the effect of abnormal moisture and drainage conditions.

The process of accumulation of the parent material, or the soil-forming material, which with soil development gave rise to Pullman silty clay loam, also Pullman silty clay loam, shallow phase, and Potter clay loam, is generally described by geologists (*11*, *12*, *13*) as that of the formation of an outwash plain at the western base of the Cordilleran system during Cenozoic times. This material within Potter County occurs as a very uniform bed, averaging about 50 feet thick, over the High Plains. Accordingly, with a uniform parent material and no change in climatic conditions within an area as small as this county, the same soil, Pullman silty clay loam, occurs everywhere over the High Plains within the county where the surface relief is smooth and the drainage normal. The soil-forming material consisted of friable highly calcareous reddish-buff clay containing a considerable amount, probably about 10 percent, of soft white or creamy-white calcareous concretions. As seen in the excavation of the Santa Fe Building in Amarillo, the only apparent variation in the character of this material was that certain layers at 18, 20, and 24 feet below the surface contained a considerably larger proportion of the calcareous concretions.

The Atterbury constants,[4] as determined on a sample of the upper subsoil layer of Pullman silty clay loam, collected at a depth ranging from 12 to 16 inches below the surface, from a typical area in the north-central part of Potter County, are as follows:

Upper plastic limit	33.3
Lower plastic limit	18.4
Plasticity number	14.9
Toughness number	1536.0
Solidity number	106.2
Percent lineal shrinkage	8.2

Table 4 gives the results of mechanical analyses and tables 5, 6, and 7 give the results of chemical analyses of Pullman silty clay loam (formerly correlated as Amarillo soil) from a sample taken near the location of the profile just described in detail (*1*).

TABLE 4.—*Mechanical analyses of Pullman silty clay loam*

Horizon	Depth	Fine gravel (2–1 mm)	Coarse sand (1–0.5 mm)	Medium sand (0.5–0.25 mm)	Fine sand (0.25–0.1 mm)	Very fine sand (0.1–0.05 mm)	Silt (0.05–0.005 mm)	Clay (<0.005 mm)	Inorganic colloid (<0.002 mm)	Loss on treatment with H_2O_2
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1	0–5	0.0	0.2	0.3	2.6	12.1	55.1	27.6	23.9	2.0
2	10–20	.0	.1	.2	1.9	8.3	41.0	47.4	42.8	1.1
3	30–40	1.0	.5	.4	1.6	6.9	45.2	43.8	37.6	.5
4	54–64	.1	.3	.4	3.4	16.6	41.2	37.9	34.6	.3
5	70–75	.1	.4	.4	2.2	9.2	34.1	53.4	35.9	.2
6	96–100	.2	.2	.3	2.1	12.2	41.0	44.0	31.3	.0

[4] RUSSEL, J. C. PRELIMINARY REPORT OF LABORATORY WORK ON SOIL CONSISTENCY. Amer. Soil Survey Assoc. Bull. 10 (Ann. meeting 9): 137–141. 1929. [Mimeographed.]

TABLE 5.—*Chemical composition of Pullman silty clay loam*

Horizon	Depth	SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	MgO	K_2O	Na_2O	TiO_2	P_2O_5	SO_3	Ignition loss	N	pH
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
1	0- 5	75 62	10 56	3 16	0 09	0 67	0 78	2 20	1 06	0 78	0 10	0 07	4 98	0 13	6 5
2	10- 20	70 48	13 88	4 40	09	97	1 35	2 56	1 01	.71	09	07	4 94	08	7 8
3	30- 40	68 72	13 25	4 31	08	2 64	1 37	2 48	1 03	74	.10	06	5 50	06	7 8
4	54- 64	74 49	11 67	3 83	06	1 09	1 10	2 14	87	95	07	21	3 82	02	7 9
5	70- 75	40 42	6 09	2 04	04	25 80	1 06	1 20	46	.42	08	13	21 82	.01	7 9
6	96-100	56 71	04	2 86	06	14 11	1 22	1 71	73	57	09	11	13 00	01	8.3

TABLE 6.—*Chemical composition of soil colloids from Pullman silty clay loam*

Horizon	Depth	SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	MgO	K_2O	Na_2O
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1	0- 5	50 51	22 04	8 80	0 14	1 48	2 08	2 68	0 06
2	10- 20	51 51	22 71	8 61	09	1 59	2 66	2.54	.01
3	30- 40	51 32	22 43	8 46	05	2 27	2 80	2 50	.06
4	54- 64	51 23	24 08	8 19	07	1 73	2.83	2.42	.10
5	70- 75	38 42	17 64	5 71	06	16 38	2 53	1 83	.06
6	96-100	45 88	20 09	6 89	05	9 05	2.87	2.26	.01

Horizon	Depth	TiO_2	P_2O_5	SO_3	CO_2	Ignition loss	Organic matter	Mols $\frac{SiO_2}{Al_2O_3+Fe_2O_3}$
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	
1	0- 5	0 56	0 20	0 18	0 00	12 08	4 02	3 10
2	10- 20	57	12	14	00	9 50	2 14	3 09
3	30- 40	58	14	14	.35	10 19	1 06	3 13
4	54- 64	55	11	13	.00	8 72	96	2.97
5	70- 75	37	09	10	11 22	17 85	42	3 06
6	96-100	52	11	13	5 87	12 41	13	3.18

TABLE 7.—*Properties of soil colloids from Pullman silty clay loam*

Horizon	Depth	Heat of wetting per gram of colloid	H_2O vapor adsorbed over 30-percent H_2SO_4 per gram of colloid	H_2O vapor adsorbed over 3 3-percent H_2SO_4 per gram of colloid	Moisture equivalent	Exchangeable bases per gram of colloid				
						Ca	Mg	K	Na	Total
	Inches	*Calories*	*Gram*	*Gram*	*Percent*	*Milliequivalents*	*Milliequivalents*	*Milliequivalents*	*Milliequivalents*	*Milliequivalents*
1	0- 5	16 8	0 154	0 300	84 3	0 389	0 159	0 034	0 006	0 588
2	10- 20	18 5	184	340	85 0	.492	149	030	.000	671
3	30- 40	18 0	182	334	85 6	.628	154	015	019	.816
4	54- 64	19 5	201	363	88 5	532	149	.019	026	728
5	70- 75	13 8	147	292	78 9	1 027	099	017	.000	1 143
6	96-100	18 0	171	331	86 6	.924	099	.015	009	1 047

Horizon	Depth	Exchangeable base capacity per gram of colloid by $BaCl_2$	Degree of saturation	Colloid content of soil determined by H_2O adsorption	Colloid content by mechanical analyses	Colloid extracted from soil	Mols $\frac{SiO_2}{Al_2O_3+Fe_2O_3}$
	Inches	*Milliequivalents*	*Percent*	*Percent*	*Percent*	*Percent*	
1	0- 5	0 566	(1)	25 7	25 9	18 2	3 10
2	10- 20	628	(1)	39 1	43 9	10 5	3 09
3	30- 40	634	(1)	35.9	38 1	13 8	3 13
4	54- 64	692	(1)	30 3	34 9	10 0	2.97
5	70- 75	656	(1)	24.1	36 1	10 5	3 06
6	96-100	.700	(1)	26.2	31 3	14.7	3 18

[1] Saturated.

The Division of Dry Land Agriculture, Bureau of Plant Industry, United States Department of Agriculture conducted extensive studies on the various moisture relations of Pullman (formerly Amarillo) silty clay loam at the cereal field station at Amarillo. These studies included determinations of the wilting coefficient, water equivalent, field-carrying capacity, and minimum point of exhaustion, in addition to many other factors, by 1-foot sections on several plats of this soil. These investigators (*5, p. 36*) state:

> While the evidence is not as complete as could be desired, it appears that the storage of water and the development of the feeding roots of the crop are interfered with by a comparatively impervious layer of soil in the third foot. The soil above this, however, is competent to take care of all the water that it has been possible to store, even under a system of alternate cropping

This statement indicates the possibility of the existence of an important feature in this soil which has not been detected under field observation. The second foot of the soil is apparently fully as plastic, tough, compact, and hard as the third foot

Pullman clay loam, as mapped, occurs in areas within the Canadian River breaks, where the soil-forming materials have been subjected to the forces of soil development for a shorter period of time, and accordingly this soil is somewhat less completely developed than Pullman silty clay loam. The red deep subsoil layer is less well developed, and many areas of Pullman clay loam show a gradation to the Fritch soils. The lighter textural character and the more friable consistence of the subsoil are probably the consequence of a parent material which was of slightly lighter textural character. The parent material of this soil is generally given the same geologic designation (undivided Cenozoic) as the parent material of Pullman silty clay loam, but it comes from lower levels of the deposit which are much less uniform in character and generally more sandy than the geologic materials at the immediate surface of the High Plains in Potter County. A few areas of Pullman clay loam occur on probable stream terraces of later origin, but they differ little, if any, in soil character from areas occurring on deposits which have not been reworked.

The soils of the Fritch series are characterized in typical development by five layers as follows: (1) A sandy, granular, dark-colored surface layer, (2) a lighter colored moderately heavy textured layer, (3) a very dark colored, very heavy textured, very plastic layer containing white crystalline salt accumulations, (4) a red sandy layer, and (5) a sandy, highly calcareous layer. The second and fourth layers of the profile described are essentially gradational and are not everywhere present in well-defined form. The highly calcareous layer lies at a depth of 6 feet or deeper. The third layer possibly represents a buried soil

The Fritch soils are prevalent on smooth surfaces in some localities but in other localities, with apparently identical conditions of topography, vegetation, and parent material, the Pullman or Zita soils prevail.

Atterbury constants determined on two layers of Fritch fine sandy loam are given in table 8.

TABLE 8.—*Atterbury constants determined from 2 layers of Fritch fine sandy loam*[1]

Description of horizon	Depth	Upper plastic limit	Lower plastic limit	Plasticity number	Toughness number	Solidity number	Lineal shrinkage
	Inches						*Percent*
Brown light fine sandy loam	0–3						
Brown heavy fine sandy loam	3–20	16 6	15 2	1 4	387	42 6	3 3
Light-brown calcareous clay loam	20–34						
Very dark brown clay	34–46	28 4	15 9	12 5	1989	104 6	6 4

[1] RUSSEL, J C PRELIMINARY REPORT OF LABORATORY WORK ON SOIL CONSISTENCY Amer Soil Survey Assoc, Bull 10 (Ann Meeting 9) 138–139 [Mimeographed]

A profile of Fritch silty clay loam as observed in the northeast corner of Potter County is described as follows:

From 0 to 4 inches, silt loam or silty clay loam, which is grayish brown when dry and dark brown when wet. The material has a slightly developed platy structure. There is no effervescence with hydrochloric acid The soil is slightly hard when dry, friable when moist, and very slightly plastic when wet.

From 4 to 24 inches, clay which is dark chocolate brown when wet and brown or reddish brown when dry. No effervescence occurs with hydrochloric acid. Slightly developed columnar build, the columns being about 2 inches in diameter and from 10 to 20 inches long. Slightly developed fine granular or spheroidal structure. The material is hard when dry, compact when moist, and plastic when wet.

From 24 to 40 inches, clay which is brown when dry. The material is calcareous and of the same consistence as that in the layer above. No definite structure

From 40 to 50 inches, clay which on a broken surface, is very dark brown when dry and black when wet. Crushed surface is dark brown when dry and very dark brown when wet. Calcareous Nut structure, the aggregates being about one-half inch in diameter and covered on the outside with a film of glistening black material. Within the structure particles are small lenses of white crystalline calcareous salts. The material is extremely plastic, extremely compact, and very hard.

From 50 to 70 inches, clay which is brown when dry. The material is calcareous It is plastic when wet, compact when moist, and hard when dry

The Richfield soils as mapped occur in very flat or slightly depressed areas having very slow drainage. The areas occupy low benches around areas of Randall clay, on the high plains. These soils have black or dark-brown surface soils which do not contain sufficient lime to effervesce with acid. Below are chocolate-brown compact nongranular subsoils which, at a depth of about 5 feet, rest on gray or bluish-gray clay containing some soft lime-carbonate concretions. Richfield clay, calcareous phase, is calcareous from the surface down, and the surface soil is dark gray. The gray deep subsoil occurs at a depth ranging from 2½ to 4 feet beneath the surface. The subsoils of all the Richfield soils show some splotching with rust brown or rust yellow. These soils are slowly drained, but the surface is never covered with water for extended periods. There is no red subsoil layer, such as characterizes the Pullman soils. The zone of carbonate accumulation is not distinctly developed, though the soft concretions in the upper part of the gray deep subsoil layer may represent some accumulation of lime.

The caliche escarpment or cap rock at the edge of the high plains is, according to the preponderance of information now available, a surface deposit only and does not extend back under the high plains as a geologic strata. According to local well drillers, in wells drilled on the high plains a few hundred feet back from the caliche escarpment or in other locations on the high plains in this area no hard caliche or white layer, such as would characterize a soft layer of high lime-carbonate content, is generally reached at a depth corresponding to the elevation of the caliche escarpment. The normal soil layer of carbonate accumulation is present at a depth of less than 7 feet beneath the surface, but below this there is no uniformly or commonly occurring indurated caliche. In one-tenth or fewer of the wells, a hard limestone, or caliche layer, most commonly about 1 foot thick, but in places reaching a maximum thickness of 10 feet, occurs just above the water-bearing strata. Such occurrences of a deep indurated caliche are most common in parts of the shallow water belts of the high plains, such as that around Hereford, Deaf Smith County, but they are not numerous even within the shallow water belts.

Other well drillers (*15*) state that a hard caliche strata is commonly present under the high plains at a depth of about 50 feet below the surface, at a level corresponding to the caliche escarpment, and they designate this layer as cap rock in the logs of their wells.

The caliche escarpment at the edge of the high plains is thickest and most prominently developed in the southwestern part of the county. It is moderately developed along the northern boundary of the Canadian River breaks in the north-central part, and along the southern boundary of the river breaks in the eastern part, in the vicinity of Masterson. It is very slightly developed and inconspicuous in the vicinity of Amarillo and entirely absent around the heads of some of the small drainageways.

Directly north of Soncy, where the caliche escarpment is well developed, it is 45 feet thick. It contains two ledges of well-indurated material, and the remainder of the exposure consists largely of sand somewhat weakly bound together with carbonate of lime. One of the ledges is about 5 feet thick and occurs at the top of the exposure; the other is about 10 feet thick and occurs about 5 feet below the upper ledge. The material of these ledges consists largely of carbonate of lime occurring as somewhat rounded nodules from 2 to 4 inches in diameter, the nodules being cemented into a solid mass. A few of the nodules, which apparently consist of siliceous material, are very hard. The caliche escarpment is 25 feet vertically below, and 400 feet horizontally from, the nearest area of soil which has a well-developed zone of carbonate accumulation. Potter clay loam, which immediately overlies the caliche escarpment at this place, has a slightly defined zone of carbonate accumulation. Accordingly, the relationship of the occurrence of this escarpment to the soils demonstrates that this thick caliche is not a mere soil zone of carbonate accumulation in exaggerated form which has been exposed by the removal of the surface soil layers.

North of Soncy the caliche occurs immediately below the point where the geological beds, consisting of the high plains deposits of the Cenozoic, change in character from an upper rather uniform clay layer to the lower sandy layer. Accordingly, the caliche occurs at the top of the sandy layer. The same condition holds generally throughout the county, as is shown by the distribution of the soils. A band of Potter clay loam commonly borders the caliche escarpment along its upper edge, and a band of Potter fine sandy loam borders the lower edge. In the vicinity of Amarillo this relationship of soils to the occurrence of the escarpment does not hold true, and in some localities within that general locality the escarpment occurs just above or within the Trujillo sandstone of the Triassic. On some of the narrow flat-topped ridges of the high plains, which extend as indentations out into the Canadian River breaks, the indurated caliche continues as a continuous ledge back from the escarpment, under the shallow soils capping the ridge.

Most of the caliche escarpment has been formed by the movement of water underground laterally to finally seep out on the face of an exposed slope where it evaporated and left the dissolved materials on the surface. However, this was not the method of formation of all the caliche or "mortar beds" which occur within the Cenozoic deposits of this area. Some caliche layers were formed before exposure during the present erosion cycle. Severely eroded beds of a maximum thickness of more than 50 feet, which superficially resemble in every way the material of the caliche escarpment, occur in the central part of the county. A representative exposure of this character is between John Ray Creek and Lahey Creek about 1 mile north of Beard Camp. This bed is highly calcareous throughout, not merely on the surface exposures, and may represent a place where deposition of carbonate of lime and cementation occurred at a former ground-water level.[6] Some parts of this lower caliche, or mortar beds, deposit have been geologically classified as Potter (*15*). The hard layers immediately overlying the water strata, as described by well drillers, may represent the same condition.

Accordingly, it should be recognized that all caliche, or mortar beds, has not been formed under exactly the same conditions. In the county, caliche has been formed as a soil zone of carbonate accumulation, as a surface deposit left by evaporation, and probably at former and present ground-water levels.

The soil parent materials of Potter County are classified geologically in three general groups as follows: (1) Undivided Cenozoic, (2) predominantly red tinted shales of the Permian and Triassic, and (3) reworked recent stream deposits, including bottoms, terraces, and colluvial benches (*15*).

The undivided Cenozoic group includes largely the deposits covering the High Plains, and throughout this report they have been generally referred to as "High Plains deposits." The most significant difference as a soil parent material within this group of deposits is that the upper part, to a depth ranging from 40 to 100 feet, consists of uniform calcareous friable clay, and the lower parts are predominantly sandy or gravelly. Accordingly, as these upper uniform deposits are those which have weathered on the High Plains to form soils, the soils of the High Plains in the county are heavy textured and uniform; and one soil, Pullman silty clay loam, con-

[6] A hypothesis advanced by Willard H. Johnson for similar deposits.

stitutes 78 percent of the typical part of that physiographic unit. The lower parts of these deposits, which have been exposed in the Canadian River Valley, have given rise to more sandy soils. The Potter, Pullman, Amarillo, Richfield, and Fritch soils have resulted from weathering of these parent materials.

The shales of the Permian and Triassic group are predominantly red tinted, very slightly consolidated or unconsolidated, rather heavy in texture, and slightly calcareous. To some extent the soils resulting from the weathering of these deposits have retained some of the red color present in this parent material. In the county, these formations are exposed only on rolling surfaces, and the soils formed on them are shallow and granular. They are classified as Weymouth soils. The sandstone ledge of the Triassic has weathered to sandy soil covering a few small areas which have been included in the Potter soils.

Table 9 gives the results of mechanical analyses of samples of the surface soil, subsurface soil, and several layers of the subsoil of Potter fine sandy loam.

TABLE 9.—*Mechanical analyses of Potter fine sandy loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
447997	Surface soil, 0 to 2 inches	0.0	0.9	4.9	30.6	32.1	15.3	16.1
447998	Subsurface soil, 2 to 7 inches	.2	4.0	12.3	31.0	23.4	13.1	15.9
447999	Subsoil, 7 to 13 inches	.4	4.2	12.5	31.7	20.5	10.8	19.9
4479100	Subsoil, 13 to 30 inches	.7	4.6	6.3	20.3	17.5	18.6	32.1
4479101	Subsoil, 30 to 96 inches	.4	3.2	7.8	30.4	28.8	14.9	14.6

SUMMARY

Potter County is located in the Panhandle of Texas. One sixth of the county is included in the High Plains and five sixths in the Canadian River Valley.

The climate is subhumid, with moderate temperatures. The average annual precipitation is 21.01 inches.

The type of agriculture practiced consists of the production of winter wheat and grain sorghums in the High Plains section and livestock ranching in the Canadian River Valley. The yield of wheat has ranged between failure and 50 bushels to the acre, averaging about 10 bushels. The yield has been increased somewhat during the last few years through better cultural practices. The yield of grain sorghums averages about 25 bushels to the acre.

The methods of farming are concerned largely with the problem of conserving and utilizing the soil moisture. Fallowing with cropping in alternate years is not commonly practiced. Terracing to conserve soil moisture and prevent soil erosion seems to offer the greatest opportunity for the improvement of cultural practices. The land has not been cultivated sufficiently long to indicate a need for fertilization or crop rotations.

Ninety percent of the typical part of the High Plains of the county is excellent agricultural land, 5 percent is fair agricultural land, and 5 percent is nonagricultural land. More than two-thirds of the

Canadian River Valley rolling land is not suited to cultivation, and the rest is largely only fair for farm crops. Three-fourths of the excellent agricultural land was devoted to crop production in 1928. Pullman silty clay loam, which is a deep, fertile, productive soil, constitutes more than three-fourths of this land.

The soils have developed under a grass vegetation. The Pullman soils are dominant on smooth surfaces. They are characterized by dark-brown noncalcareous surface soils over dark chocolate-brown compact clay upper subsoil layers which are underlain by yellowish-red lower subsoil layers overlying a soft layer of carbonate of lime accumulation.

The Amarillo, Zita, Fritch, Richfield, Weymouth, Enterprise, and Randall soils are other upland soils extensively developed within the county. The Miller, Yahola, and Spur soils are recent-alluvial bottom-land soils.

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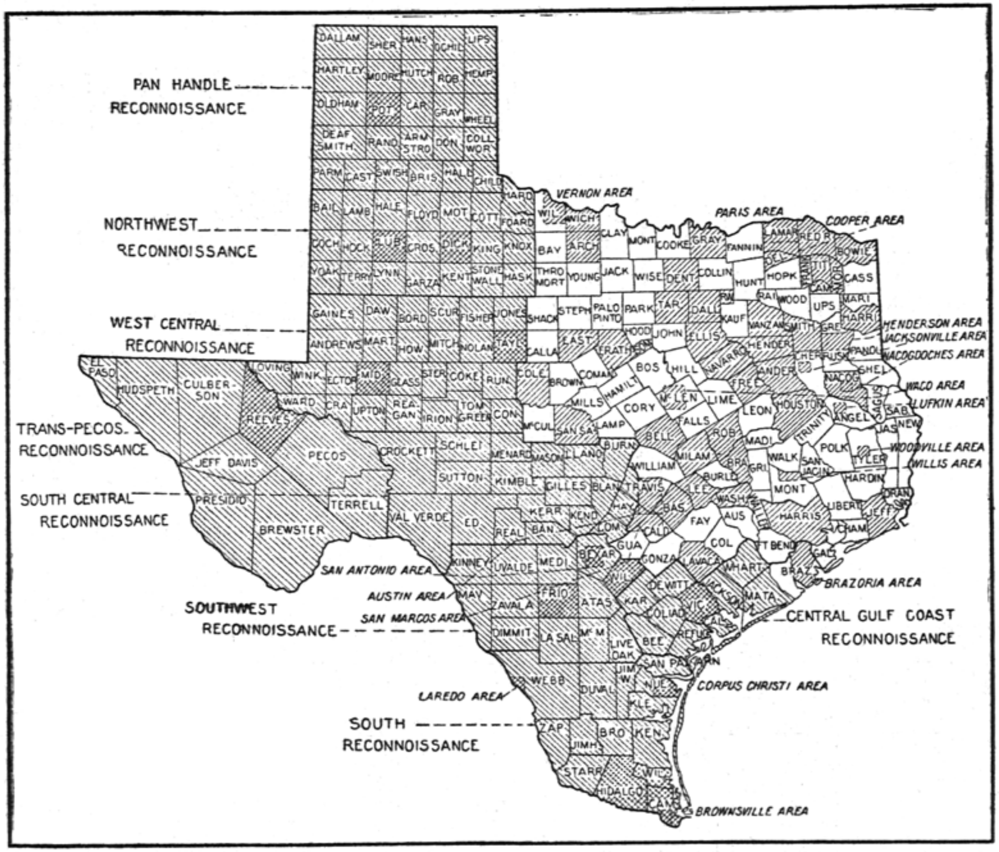

Areas surveyed in Texas, shown by shading. Detailed surveys shown by northeast-southwest hatching; reconnaissance surveys shown by northwest-southeast hatching; cross-hatching indicates areas covered in both ways.

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