RECONNOISSANCE SOIL SURVEY OF WESTERN KANSAS.

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GENERAL DESCRIPTION OF THE AREA.

LOCATION.

The soil survey of western Kansas covers an area of 39,960 square miles, or nearly one-half of the total area of the State. Forty-six counties make up the area of which the tier composed of Smith,

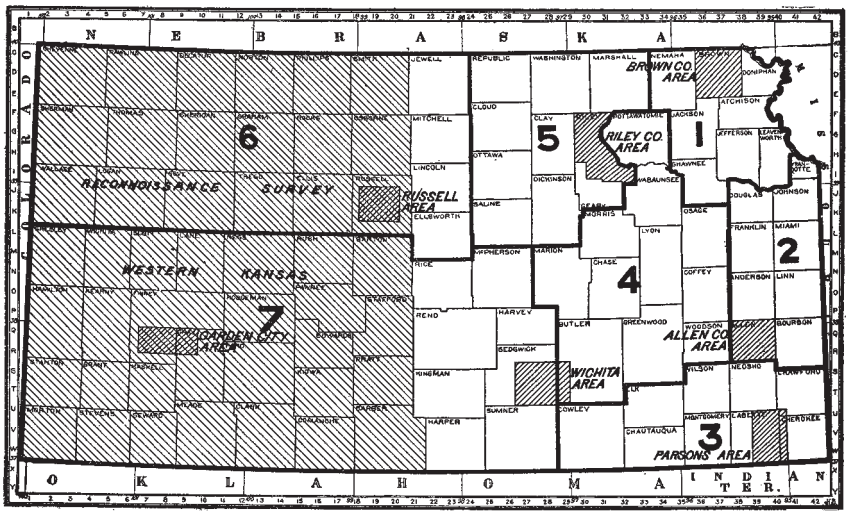

FIG. 41.—Sketch map showing location of the western Kansas reconnoissance.

Osborne, Russell, Barton, Stafford, Pratt, and Barber form the eastern boundary. It holds a geographical position between the parallels 37° and 40° north latitude, which are also the northern and southern State lines. The eastern boundary follows closely the meridian 98° 30′, extending slightly east of it in the southeastern corner, and a few miles west of it toward the northeastern part.

GENERAL SURFACE FEATURES.

The area surveyed lies wholly within the physiographic province known as the Great Plains. Its general configuration is that of a vast, treeless plain, sloping gradually eastward, dissected by numerous parallel eastward-flowing streams. The ascent from an elevation of about 1,300 feet in the southeastern part of the area to that of more than 4,000 feet along the western edge of the State is at an average rate of about 10 feet per mile, though the inclination is more rapid toward the western part.

The principal difference in the character of the topography in various parts of the State is due to the amount and character of the erosion that has taken effect upon a once nearly level plain, and of course primarily to the hardness of the rocks upon which the streams have acted, to the character of the drainage channels, and the amount of water carried.

In the eastern part of the area, where the streams have grown large and the local rainfall is heavier, the dissection of the plains has gone on more rapidly and has given the country a rolling topography with few level areas, though extensive areas on the divides are well suited to farming. Toward the west streams are less frequent, and the decrease in the amount of rainfall has so lessened local run-off that erosion has been much reduced. Drainage systems have not been extended far into the plains, and the country is left in level or gently rolling flats cut by abrupt and comparatively narrow stream valleys. The uneroded portions of the plateau form the vast level plains in the western part of the State. Some of them are so nearly level that hundreds of square miles have no surface run-off, and the rainfall either sinks into the ground or evaporates. The largest of these level areas is the one between the Smoky Hill and Arkansas Rivers, covering parts of Greeley, Wichita, Scott, Hamilton, and Kearny Counties. Another lies south of the Arkansas and comprises parts of Haskell and the surrounding counties.

The region north of the Arkansas Valley, which is largely included within the Kansas drainage basin, has the same general surface features. The descriptions of topography apply to regions where the soils are derived from the limestone or shales, as well as to those covered by loess, since the soils are so similar that their method of weathering is the same, and in either case the removal of the soil covering exposes the calcareous rocks of the Niobrara and Benton formations. The divides constituting the greater part of the area may be described as rolling, the topography ranging from a gently undulating plain to sharply eroded hills traversed by numerous drainage channels. The slopes, however, in this character of topography are usually smoothed over, well grassed, and suitable for farming.

This region is broken at intervals by streams which, by cutting through the soft soil covering, have exposed the underlying limestone and produced a very different topography from those having their beds in the silty materials. The larger creeks occur at intervals of from 10 to 20 miles, but the tributaries and minor channels cut back many miles into the plains. The topography of the slopes is not uniform. For long distances the approach to the watercourses may be gradual and the hillsides fairly well smoothed over, but it is common to find strips of stony and rough land flanking the streams. The removal of the silty surface soil and the unequal weathering of the limestones have produced strips of rough, stony land, locally known as "breaks," along the creeks of the central and northern portions of the area. The steepness of the slope varies with the character of the rock. Usually breaking gently from the plains, the descent is gradual but uniformly rapid until near the stream, where, if the soft shales of the Pierre or Niobrara formations are penetrated, there is an abrupt drop to the watercourse. There is nearly everywhere along the creeks a persistent strip of alluvial flood plain through which the stream meanders. The total area of these bottom lands is not large, but it is of great importance agriculturally, as it comprises a large part of the subirrigated alfalfa land of the area.

South of the more or less dissected plains comes the valley of the Arkansas River. This valley is flanked on the north by the deposits of loess, plains marl, or silty soils derived from the limestones. The incoming tributaries of the Arkansas have carved this slope into a rolling hilly region, but with no "bad lands" or other excessively eroded country. The immediate valley of the Arkansas differs from that of the other streams of the area. It is very shallow, the river not having cut its bed as deep as some of the minor watercourses on either side. Its flood plain is much broader and it is more choked with sand and gravel brought down from the mountains farther west. The hills and bluffs that border the flood plain are usually rounded, and no extensive areas are too rough to be farmed.

On the southern slope of the Arkansas there begins a series of sandhills, consisting of wind-blown sand collected into the typical dune shapes. The individual hills vary in height and area covered, but the average height ranges from 40 to 60 feet above the surrounding country. Near the river some of the newer hills are drifting, and many others are liable to be set in motion if the surface is disturbed or the vegetation is destroyed. The older sandhills, however, have ceased to move, either because vegetation has bound the sand particles or because weathering has proceeded so far that these hills have a loam soil which is not so readily moved by the wind. The sandhills bordering the Arkansas occupy a strip varying in width from nothing to more than 20 miles. South of this strip

the hills are not continuous, but sand ridges and sandy soils run in irregular ridges to the southern part of the State. The sandhills have a characteristic vegetation consisting of yucca and coarse grasses.

The Cimarron, the Medicine Lodge, and a number of smaller creeks in the southeastern part of the area have produced a characteristic topography where they have passed through the Permian Red Beds. This formation, containing readily soluble beds of salt and gypsum succumbs rapidly to the agencies of erosion. The result of stream action in these soft materials has been to produce deeper valleys and in some places more ragged, broken country than is found elsewhere in the area. In some parts of the area covered by this formation the hills are smoothed over and the soils are weathered to a considerable depth, but usually where the Red Beds are completely exposed there is a large proportion of land badly eroded. Along the creeks every incoming stream and local drain cuts sharp valleys and gullies. In the badly eroded country the naturally fertile soil is left bare of vegetation. Farther away from the streams there are comparatively level divides and slopes where good farming land is found. Over a large stretch of country southeast of Coldwater so much of the surface has been eroded that the remnants of original plains stand up in irregular narrow ridges, rising abruptly, as the Tertiary material with which the divides are capped has protected the Permian formation from rapid erosion.

On the border of the Permian outcrop the topography is influenced to a long distance by the removal of the salt and gypsum beds under the harder rocks and their subsequent tumbling down on the border to form rough, stony land, or by subsidence farther back to form depressions. It is this process that accounts for numerous valleys that can not be ascribed to erosion by the usual stream action. The most notable of these valleys are those located near Ashland and Meade, respectively. In both cases valleys have been produced much larger than has ever been necessary for the use of the streams. North and west of Ashland solution has taken place under hard calcareous rocks, and to this agency is partly due the area of rough, stony land in that section. It is in this region also that we find the sink holes, ranging in size from several hundred yards in diameter to small pools and wells. The best known of these is St. Jacobs Well, 12 miles northwest of Ashland.

The topography of the entire southern part of Kansas is influenced at intervals by this subsidence over salt beds. The Cheyenne Bottoms south of Hoisington, and far from the exposure of any Permian formation, undoubtedly owe their origin to this process. Here a deep basin measuring 7½ miles from north to south and 11 miles from east to west has been depressed to such a depth that drainage is restricted and in rainy seasons water stands over nearly the whole of it.

Scattered over a large portion of western Kansas, but more thickly over the silt-covered plains south of Minneola and north of the Arkansas within a radius of 30 miles around Garden City, are numerous saucer-shaped depressions, locally known as "buffalo wallows." They may range in size from a few feet to a quarter of a mile in diameter, but the usual diameter is from 100 to 200 feet. They are shallow, ranging from 1 to 3 feet in depth. These depressions were originally started by unequal ground settlement, though it is very probable that in many cases they have been deepened, in accordance with the popular belief, by the pawing of the buffalo and the removal of dust thus loosened by wind, or by the wallowing of the animals and the carrying away of the material as adhering mud.

REGIONAL DRAINAGE.

The slope of western Kansas is in a general way eastward, and at a uniform rate for all parts of the State having the same relative distance east and west. The streams for the most part pursue a nearly eastward course, the exceptions being a few streams in the extreme southeastern part of the area which leave the State in a southeastward direction. There are three general drainage basins in the area, the Kansas, the Arkansas, and the Cimarron, and each has some characteristic features of erosion and of sedimentation.

The region drained by the Kansas River includes the whole of the area north of the comparatively narrow Arkansas Valley. The creeks of this system which finally converge into the Kansas River occur at intervals of from 10 to 20 miles, if only the main branches are considered. They pursue a general direction remarkably near due east, with the exception of those in the northwestern part of the State, which flow northeastward into the edge of Nebraska, where they join the eastward-flowing Republican River. The principal systems south of the Republican tributaries are those of the Solomon, the Saline, and the Smoky Hill. All of these have numerous tributaries, which diverge at an acute angle from the main stream, so that most of the watercourses keep an east and west course. Some of the largest of these creeks have a flow of water at all times of the year, but most of them are intermittent, with occasional pools of water fed by seepage or at intervals with short stretches of running water from some spring. In times of heavy rainfall all of these stream channels carry a large amount of run-off, but on account of the rolling character of the plains this water is soon disposed of and they resume their normal condition.

The Arkansas River rises in the Rocky Mountains and enters the State of Kansas about 70 miles from its southwestern corner. After flowing more than 130 miles toward the southeast it turns

sharply northwest, maintaining that direction for 70 miles, to a point near Great Bend, where it turns southeast again and in a short distance passes out of the area. In the western half of the area surveyed the tributaries of the Arkansas are small, intermittent, and of no importance. In the eastern part Walnut Creek and Pawnee River on the north side and Rattlesnake Creek on the south are streams of some size. This river differs from all other streams of the area in having a large subsurface flow through the mass of sand and gravel that composes its bed. In most places this underflow is probably much greater than the amount of water carried in its channel, for at the Kansas-Colorado line the movement of water in the channel is usually very small, and at times the whole flow is absorbed into the débris of the stream bed. This occurs at intervals along its course in seasons of low water, and in times of great scarcity of water from the mountain sources it may be dry in nearly its whole length through the area. The underground source of water is extensively drawn upon in the Arkansas Valley for irrigation. The underflow gradually reappears toward the eastern part of the area, augmented by lateral seepage, until when this stream leaves the area, below the town of Ellinwood, it is of considerable size when at its average volume. But even here the flow carried by the channel does not represent the total volume of the river, as there is still a large subsurface flow in the gravel beds.

The Cimarron rises in the foothills of the Rocky Mountains, enters the State at its southwest corner, flows northeast about 50 miles, then southeast back to the State line, and finally leaves the State in Comanche County, nearly south of Protection. It does not carry so much of the sand and gravel débris from the mountain rocks as the Arkansas. In its lower course, in common with Salt Fork, Medicine Lodge, and a few smaller streams in the southeastern part of the area, local erosion of the Red Beds has caused the deposition of a flood plain of different material from that in the valleys of the streams to the north. The watercourses of this section of the State have a more permanent flow than those having drainage basins of like area in the northern part of the State, as they are more often fed by strong springs which form an outlet for extensive underground waters.

POPULATION.

The population in western Kansas is greater per square mile in the eastern counties of the area, and diminishes gradually toward the west, in proportion to the rainfall and average crop production. Between 1890 and 1900 a few counties in the western half of the State made slight gains in population, but most of them, especially in the western part, sustained heavy losses, amounting, in some cases, to

more than 50 per cent. In the last decade, however, all counties in the area made large gains, and in nearly every case now surpass their former total. While the gains have been greater in the more thickly settled counties in the eastern part of the area, the percentage of increase has been larger in the western counties, which in many cases have doubled and trebled their inhabitants in the last 10 years.

The following table has been compiled to show the changes in population in the area surveyed for the past 20 years. To indicate more effectively the greater severity of drought toward the west, three groups have been formed, respectively comprising 15 eastern counties of the area, 16 of the central, and 15 of the western, and the total populations for those groups are given for 1890, 1900, and 1910.

Group.	1910	1900	1890
Eastern counties	161,225	124,641	121,863
Central counties	93,455	57,635	61,273
Western counties	47,594	25,964	38,712

Towns have sprung up and increased in size in proportion to the increase in the rural population, but there is still not a town in the whole area that exceeds 5,000 inhabitants. Nearly every county has as its county seat a town of from 1,000 to 3,000 people, while the latter figure may be exceeded by towns with a more extensive trade, such as Pratt, Great Bend, Dodge City, and Garden City. Usually in each county there have grown up, at railroad stations, small towns and villages which serve as trading points for the surrounding country and supply shipping facilities for wheat and other agricultural products.

The native-born portion of the population of Kansas has been drawn from all parts of the United States. Many of the settlers have come to this section after first locating in the eastern part of the State and later coming on to the west with the gradual spread of agriculture in this direction. The greater part of the recent influx of homeseekers has been from the older agricultural States, such as Illinois and Iowa, where the high price of land has tempted the owners to part with their holdings and seek homes in the cheaper lands of the semiarid West. They usually come with capital and are therefore far more likely to succeed than were the early pioneers who first homesteaded the country.

Rural settlements, covering in some places several townships, made up of farmers of foreign nationality, are found in nearly every county of the State. Besides these, many individual farmers of foreign birth or parentage are scattered throughout the area. Germans, Russian-Germans, and Bohemians are most numerous among the foreign population, though nearly every European nation-

ality is represented. A few representatives of the Scandinavian people are found, but they did not settle in Kansas so thickly as in the Dakotas and Minnesota. As a rule these foreign people succeed in farming better than the native Americans. They do not give up so quickly in the face of reverses, as it is not so easy for them to return to their original homes as for the settlers from the neighboring States. They are also very careful farmers, practice a closer economy, and to many of them accustomed to farming a poor soil under adverse climatic conditions the difficulties of wresting a living from the semiarid plains does not seem so insurmountable.

The population of western Kansas will probably continue to increase for many years to come, with fluctuations from time to time due to poor and good years in crop production. There is a vast area in the western part of the State that is not yet included in even the most extensive system of agriculture. None of the country is thickly settled, and as more than half the area has one person to every 125 to 1,000 acres, or approximately 625 to 5,000 acres to the family, settlement should proceed until the agricultural resources of the region are more nearly developed. The extent to which this can go has not been definitely determined as yet, but this section can never be as thickly settled as the more humid portions of the State. It will always be a region of extensive farm practice, and probably the final development along agricultural lines will be a system of combined farming and stock raising, and such a system will not admit of a very dense population.

TRANSPORTATION FACILITIES.

For a country so thinly settled, western Kansas is well supplied with railroads, the lines of four great transcontinental systems traversing the State. There are two main lines of the Chicago, Rock Island & Pacific in the area, one passing along the northern border, the other through the southeastern corner. A main line of the Atchison, Topeka & Santa Fe follows along the Arkansas Valley in its course through the area. North of this, the Missouri Pacific passes along the level divide extending west from Hoisington and passes out of the State through Greeley County. The Union Pacific traverses the next tier of counties from Russell on the east to Wallace on the west. In addition to the main lines, there are several branch lines of these systems, but nearly all of them have the same general east-and-west direction. This part of the State has been inconvenienced by the lack of transportation facilities in a north-and-south direction, but some relief has been afforded by the building of the branch road of the Union Pacific from Colby to Oakley and the road from Garden City to Scott. The lack of north-and-south

roads is due to the fact that most of the freight both to and from the area moves in an east-and-west direction, and also because the cost of construction of roads north and south is very much greater than in the other direction, where they can follow stream courses or along nearly level divides.

The country roads in this section are generally good at all times of the year. The silty soils make a firm roadbed, and in the dry climate they can easily be kept in repair. Some of the roads in the bottom lands get into a very muddy condition at times, but they dry off very quickly when the rains cease.

The worst roads of the area are those through the sandhills or through the very sandy soils, where the sand works up so loose that it is impossible to haul heavy loads over them. In some counties the roads are being improved by a covering of the calcareous material that is usually available at no great depth. The best example may be seen south of Garden City, where the main roads have been made as good as any in the area.

MARKETS.

At all towns along the railroads facilities are provided for buying, storing, and shipping wheat, which is the principal commodity of export. The elevators are operated by companies for profit, or by the farmers in mutual associations, are the market places for grain of all kinds, hay, and country produce, and in many places they supply the farmers with coal and other necessities. A considerable proportion of the wheat grown is ground into flour at mills located in several of the larger towns. Some of the alfalfa is ground into meal for feed. Cattle are pastured in considerable numbers, and some are finished for market. Both feeders and beeves are usually shipped to the Kansas City market.

In the eastern part of the area dairying is an important industry. Not only are the local towns supplied, but a large quantity of milk is made into butter by the creameries for shipment to other sections. In all parts of the State the dairying interests are able to supply local needs.

FORESTS.

The native timber growth of the area is confined to a scattering fringe of trees along some of the watercourses, the largest bodies lying in the bends of the Arkansas River. These groves are made up principally of elm, cottonwood, and oaks. The uplands are entirely treeless, except for occasional groves that have been planted and cared for around the farms and ranches. The cultivation of trees is a matter of some difficulty in all parts of the area, but in the eastern counties all trees that are native to the subirrigated valleys may be started on the upland with the exercise of a little care, and in

addition the catalpa is grown widely for posts as far west as Dodge City. The difficulty in growing trees increases toward the west, and the number of species suited to the drier climate becomes more restricted. In some places in the extreme western side of the State the Russian mulberry and several species of pine may be grown under certain conditions, but in most places the cedar is the only tree that gives any promise of success.

The United States forest reserve stretches from Garden City westward in irregular blocks along the range of sand hills south of the Arkansas River. The worthlessness of these lands for farming purposes suggested their utilization for timber growing, and for this purpose the reserve is maintained. At the nurseries trees of several species are being grown in order to determine which will be successful on the sand hills.

CLIMATE.

Two factors, soils and climate, determine the adaptability of a region for any particular system of agriculture. The soils of Kansas being of high average fertility, there is left to be considered the variable element of climate. In the past the agricultural development of this area has been held in check by climatic conditions and the future must be judged by this experience. In this report not only the success and failures of the farmers have been taken into consideration in estimating the agricultural prospects for the future, but also the records of the Weather Bureau, which have accumulated since the region was first settled. The observations taken in nearly every county of the State, fairly complete at many stations, give reliable data for many years, from which the true average can be closely calculated.

The climatic features considered in this report are temperature, precipitation, evaporation, and winds.

TEMPERATURE.

The table on the following page gives the highest, lowest, and mean monthly and annual temperature at points in different parts of the area.

It will be seen from the table that this section, like other parts of the Great Plains, is characterized by a wide range of monthly and annual extremes of temperature. The annual mean varies slightly in different parts of the area, ranging from 51° F. in the northwestern part to a little more than 57° F. in the southeast. The extremes range from an absolute minimum of —31° F. as recorded at Colby to an absolute maximum of 113° F. at Ashland. The extremely low temperatures occur as cold waves or blizzards, accompanied in the beginning by a high wind and usually lasting from three days to a week. It is generally conceded that the dryness of the atmosphere

on the plains renders the severe cold more endurable than the same temperatures would be farther east. These blizzards, once so destructive of range cattle, now do little damage, since animals are protected and fed. The high temperatures of summer may last a week or more, the mercury rising to 100° F. or above during the day and often not dropping below 90° F. at night.

Month.	Ellinwood.			Coldwater.			Hays.			Colby.		
	Highest.	Lowest.	Average.	Highest.	Lowest.	Average.	Highest.	Lowest.	Average.	Highest.	Lowest.	Average.
January	71	−18	30.6	75	−12	30.8	75	−15	30.1	72	−26	28.9
February	78	−21	29.1	82	−14	33.5	80	−24	28.1	77	−31	26.6
March	97	− 3	41.6	98	3	43.2	97	− 7	41.3	94	−11	38.4
April	100	14	55.3	93	16	57.4	99	2	53.4	95	8	50.8
May	102	25	64.3	102	25	65.2	104	17	63.1	100	17	60.6
June	102	41	71.4	108	45	75.4	109	31	71.6	106	35	70.0
July	106	48	77.5	110	51	78.6	110	42	76.8	107	43	75.4
August	107	46	77.8	106	49	76.8	108	36	76.9	108	41	74.6
September	101	32	69.0	105	32	71.4	104	20	68.2	107	25	65.4
October	92	22	57.7	89	26	59.3	96	12	56.2	99	12	53.1
November	83	− 3	42.4	81	0	42.0	85	− 6	40.4	81	−11	39.2
December	70	− 8	32.5	75	−14	35.1	78	−21	31.7	74	−21	30.1
Annual	107	−21	54.1	110	−24	55.7	110	−24	53.9	108	−31	51.1

FROSTS.

The interval between the probable dates of the last killing frost in the spring and the first in the fall ranges from 150 days in the northern part of the area to 185 days in the southern, giving ample time for the maturity of corn, kafir, and other crops if planted in season.

The table below shows the average dates of frosts at stations in different parts of the area:

Stations.	Length of record, years.	Average date of—	
		Last killing frost in spring.	First killing frost in autumn.
Hays	13	May 5	Oct. 5
Colby	18	May 2	Oct. 5
Wallace	15	Apr. 22	Oct. 2
Medicine Lodge	11	Apr. 12	Oct. 18
Garden City	15	Apr. 30	Oct. 11

PRECIPITATION.

The question of rainfall is of vital importance throughout the Great Plains region, for the reason that the average precipitation

is so near the minimum required for profitable agriculture. Even in sections of heavy precipitation in the East, droughts occasionally cause heavy losses to the farmer, but here slight deficiencies during the growing season more frequently cause crop failures. In estimating for any section the supply of moisture for the needs of the crops, other factors than the total annual rainfall must be taken into consideration. The prospective settlers too often note only the rainfall for one year or for a series of years, without regarding the seasonal distribution, rate of falling, run-off, evaporation, and several other factors. The first step should be to ascertain the average annual precipitation and its probable distribution as shown by the most complete records that can be obtained. When these records are favorable there is still an element of uncertainty, since the summer rains usually come as local showers and a particular locality may be passed by for several years and have crop failures, while nearby communities may have unusually large crops. These areas, however, are exceptional, and as a rule the agricultural prosperity in different parts of the State is directly proportional to the average annual rainfall. The seasonal distribution is also fairly constant in different sections and well suited to the needs of the farmer of the semiarid region, as three-fourths of it comes during the six months of the growing season.

The mean annual rainfall decreases steadily from the eastern to the western side of the area, and ranges in amount at various points of observation from 25.79 inches at Ellinwood to 16.27 inches at Lakin. Only a small portion of the area has more than 25 inches of rain, and barely half has less than 20 inches.

The table below gives the monthly and annual mean precipitation for several points representative of conditions over the region:

Month.	Wallace.	Oberlin.	Colby.	Hays.	Dodge City.	Ellinwood.	Hugoton.[1]	Coldwater.	Viroqua.
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
January	0.24	0.41	0.26	0.61	0.45	0.76	0.53	0.79	0.45
February	.45	.86	.54	.85	.68	1.02	.30	.74	.70
March	.52	1.37	.75	1.05	.74	1.26	1.27	1.20	.67
April	1.82	3.02	2.30	2.34	1.77	2.18	2.87	1.55	1.80
May	2.63	3.17	2.27	3.31	3.08	3.44	1.33	1.98	2.18
June	2.50	3.28	3.28	3.08	3.17	4.43	3.64	3.75	2.44
July	3.34	3.62	2.57	3.52	2.89	3.98	3.65	3.44	3.47
August	1.97	2.89	2.45	3.03	2.45	3.08	1.89	2.38	1.77
September	1.32	1.80	1.41	2.41	1.86	2.19	2.19	2.26	2.15
October	.94	1.24	1.10	1.56	1.35	1.89	1.22	1.75	1.15
November	.47	.63	.51	.72	.59	.85	1.08	.73	.56
December	.44	.61	.36	.41	.57	.71	.32	.68	.66
Annual	16.66	22.90	17.80	22.89	19.60	25.79	20.29	21.25	18.00

[1] Records for this station are fragmentary.

The Great Plains may be divided into north and south belts, based upon the decrease in rainfall from east to west and upon the effect of this variation as shown by crop yields and the degree of soil weathering. (See fig. 42.) In the portion of Kansas covered by this survey three of these divisions may be made. These changes, due to differences in precipitation, are so gradual that no sharp boundaries can be drawn, and any lines of demarcation are purely arbitrary as to position. The most humid belt may include the country where the annual rainfall exceeds 23 inches, or the greater part of the eastern two tiers of counties. Here failures from drought are rare and a wide range of crops may be grown. Corn is produced with profit, and alfalfa, while confined to the valleys, yields much heavier crops than in the drier sections. Trees of many species may be started on the uplands without difficulty, and fruit trees, particularly apples, do

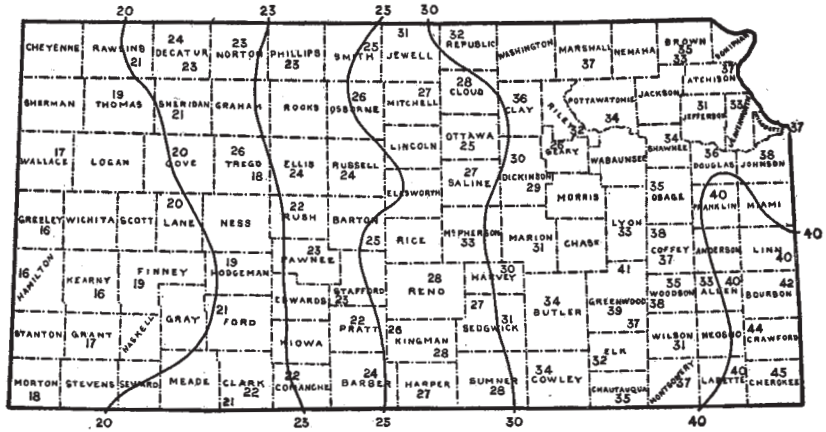

FIG. 42.—Rainfall map of Kansas. The figures show the average annual rainfall in inches.

well. The catalpa is extensively grown for posts. The soils in this region are more deeply weathered and have a smaller quantity of lime and soluble salts than the soils in the drier sections of the State.

The second belt is approximately between the lines of 23 and 20 inches, and has a width of about 60 miles. Crop yields are more uncertain by reason of droughts that occasionally cause partial or total failures. The average crop, however, is profitable, and is sufficient to support the population now resident in this belt. Corn, though extensively grown, is barely profitable, but small grains are successful when a long series of years is considered. Alfalfa is confined to the subirrigated stream valleys. Kafir and milo maize are safe crops. Trees are of few species, and, while they will grow on the uplands, it is more difficult to keep them alive in the early stages of growth. Apples and other tree fruits are not profitable except in favored localities. The soils in this section are not so leached as in

the eastern section and are richer in the soluble salts, but there are no dangerous accumulations of alkali as in the arid regions.

The third division includes that portion of the State that has less than 20 inches of rain. In this section the early settlers failed and the country was almost depopulated. Settlement has again taken place to the extreme western edge of the State, but farming may still be regarded as precarious, for the average crop is barely profitable. Agriculture will probably be made a success by the better class of farmers who make use of the best methods of conserving the soil moisture. In this section of the State the crops on unirrigated land are principally small grains and the sorghums. Corn is not a profitable crop, and alfalfa is confined to valleys that are well subirrigated. The native timber grows near the streams and on the uplands only the most hardy species of drought-resisting trees, like the cedar, will survive. The soils in this section are usually not deeply weathered, and soluble salts are present in considerable quantities. In some of the valleys alkali accumulates in quantities sufficient to affect crops, but on the upland this will not take place. The sketch map (fig. 2) shows the approximate variation in rainfall.

EVAPORATION.

The rainfall as given by the records would in the more northern regions indicate sufficient moisture to produce abundant crops. In Montana and North Dakota 15 inches of rain is equal in its effect on crop growth to more than 20 inches in western Kansas. The great climatic deficiency which reduces the usefulness of the rainfall is excessive evaporation, although the more torrential character of the precipitation is also an important factor. How great this is may be seen when it is noted that at Williston, N. Dak., the evaporation from an open tank during six months of the year was 30 inches, while at Hays, Kans., it was 45 inches, and at Garden City nearly 60 inches. Though the rate of evaporation from various soils may differ, the average loss from the average wet soil is approximately that from the surface of an exposed tank, but decreases as the soil becomes drier.[1]

It will be seen from this how difficult is the retention of 20 inches of rainfall in a region where excessive evaporation is favored by the low relative humidity, the almost continuous sunshine, and the prevalence of strong and sometimes hot winds.

WINDS.

The conservation of moisture on the Plains would be a problem in a still atmosphere, but here the difficulty is complicated by the wind movement. Not only do the hot, dry winds so prevalent during the summer months accelerate the removal of moisture by evapora-

[1] Dry Farming in Relation to Rainfall and Evaporation, Bul. 188, Bureau of Plant Industry, U. S. Dept. of Agr.

tion, but they make difficult the employment of dust mulches, so desirable in any system of dry farming, so that they are a source of danger from the time the land is broken for planting until the crop is matured.

CHANGE OF CLIMATE.

The fallacy that any change of climate of a permanent nature has taken place, resulting in an increase of rainfall, is not held to any extent in Kansas. The official records, as well as the experience of the farmers, effectually dispose of any such contention and demonstrate clearly that any recent oscillations of rainfall in either direction should be disregarded in considering the future of the region. Nearly all the farmers recognize the deficiencies of the climate and hold no unwarranted theories as to any change in the future. In spite of many failures in the extreme western part of the State, the depopulation of some sections, the pressure of population, and the increasing demand for agricultural products assure the development of the agricultural resources of the entire region surveyed.

SOILS.

GENERAL DISCUSSION.

Soil constitutes the superficial portion of the earth's surface which may furnish a suitable medium for the growth of plants. It consists of particles of broken-down rocks mixed more or less with the remains of plant and animal life. Having been derived from the underlying formations through the action of certain processes known as weathering, its character will vary according to differences in these two sets of factors. A knowledge, therefore, of the geological formations found in western Kansas, as well as the general processes which have changed these into actual cultivable soils, is essential to a proper understanding of the true nature and properties of the soils.

RELATION OF SOILS TO GEOLOGICAL FORMATIONS.

In studying the influences of the geological formations, it is not so much their age as the character of material composing them which must be considered. Formations of different ages may be composed of very similar material, while others which are contemporaneous may be very unlike in character, and for this reason a geological map and a soil map may show many discrepancies. In this area some of the soils derived from even as widely separated formations as the Cretaceous and Quaternary are so nearly identical that it is often difficult to draw the line of division between them.

The oldest geological[1] formation in the area is the Permian Red Beds, which outcrop in the southeastern part of the survey. This

[1] The discussion of the geology is based largely upon the "Preliminary Report on the Geology and Underground Water Resources of the Central Great Plains," by N. H. Darton, Professional Paper No. 32, United States Geological Survey.

formation consists mainly of fine-grained sandstones and shales, containing thick beds of gypsum. These Red Beds give rise to the red soils of the Vernon series.

Above the Red Beds occur a number of formations of Cretaceous age. Although these rocks underlie almost the entire area surveyed, the principal outcrops are in the east-central part.

The Comanche series, consisting of a lower stratum of sandstone (Cheyenne) with thin layers of limestone, outcrops as a narrow band in the extreme southeastern part, one of the best developments being in the vicinity of Belvidere. Most of the country here is rough and broken, but a few fairly level areas were separated as the Belvidere silt loam.

The Dakota formation, consisting mainly of sandstones, but also containing considerable shales, is the next oldest. It outcrops principally in southern Barton and Pawnee Counties, but small areas are found elsewhere. The sandstone is porous, furnishing excellent conditions for the storage of underground waters, and for this reason is of much economic importance. Being harder than the shales, it is more likely to form steep bluffs, so that the outcrop covers only a small area.

The Benton group, which overlies the Dakota formation, outcrops in a rather broad belt extending northeastward from Hodgeman and Ness Counties, while another small area occurs in the upper Arkansas Valley. Most of the latter, however, is overlain by later deposits. The lower or basal member is a dark shale (Graneros), the middle largely limestone (Greenhorn), while the upper part is almost entirely shale (Carlile). Several different horizons of the Greenhorn limestone have been recognized in the Kansas Geological Survey Reports; the most conspicuous is the "Fence post" horizon, so named because it consists of a sheet of limestone averaging about 9 inches thick, which furnishes excellent material for fence posts, a matter of considerable agricultural importance in an area with practically no timber.

Above the Benton group occurs the Niobrara formation, consisting of chalk, soft limestones, and shales.

The soils from different layers of Cretaceous shales are very similar in character, and have been mapped as the Summit silt loam and silty clay loam. Likewise those from the different limestones have been included in the same type and called Benton stony loam.

Over the greater proportion of western Kansas the surface material consists of unconsolidated or slightly consolidated deposits of Tertiary and Quaternary age, which are so nearly alike in character that it is often impossible to distinguish between them except by the fossils. Even the loess, which covers most of the northwestern part

FIG. 1.—BADLY ERODED AREA IN THE VERNON SILT LOAM NEAR KIOWA, KANS.

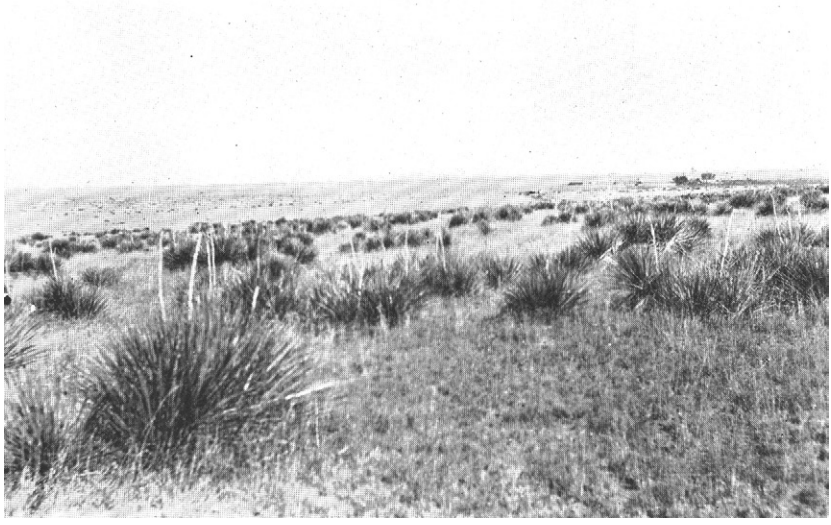

FIG. 2.—CHARACTERISTIC GROWTH OF YUCCA ON THE RICHFIELD SANDY LOAM NORTH OF JOHNSON, KANS.

FIG. 1.—HARVESTING WHEAT.

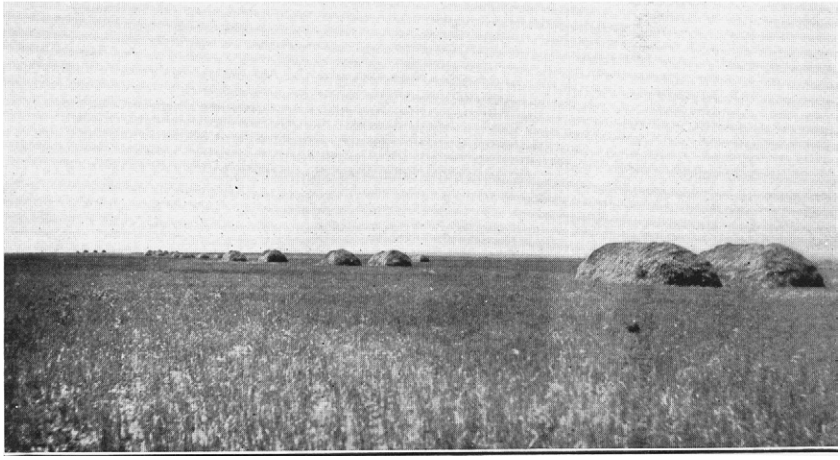

FIG. 2.—A STRING OF STRAW STACKS ON THE ALLUVIAL SOILS IN PAWNEE COUNTY, KANS.

of the State, can hardly be told from the silty layers found in the Tertiary.

These Tertiary deposits are thought to represent a great alluvial fan or débris apron, brought down from the mountains to the west, by the streams, and spread out over the plains to the east. Either a tilting of the surface or a change in climatic conditions reduced the carrying power of the streams, which, overloaded with sediments, filled up their old channels and made new ones. By this continuous shifting a series of aggradation deposits was built up. Where the currents were strong coarse material such as gravel and sand was left, while the finer particles were deposited in the slack waters or temporary lakes between the stream channels. It is also probable that some of the material was shifted more or less by the wind.

Owing to the method of formation, these deposits as a whole consist of rather irregular layers or lentils of gravelly sands, silt, or clays, the different textured material occurring in various positions as regards elevation and in case of the coarse material particularly without continuity for any great distance. In general, the percentage of sand and gravel is greater near the base of the Tertiary than in the upper portion, and for this reason the sandy or gravelly material most often occurs where the streams have cut considerable valleys in the Tertiary deposits, although some is found on the level uplands. The large proportion, however, of the uneroded plains are covered by a deposit of a pale yellowish mealy silt, sometimes called the Plains Marl.

In the eastern part of the area the Tertiary deposits have a slightly reddish color, are not very calcareous, and the resultant soils are included in the Pratt series. A little farther west they lose their reddish color and have given rise to the Greensburg silt loam and silty clay loam. Farther west the material is more calcareous, and the soils are included in the Richfield series.

Throughout the Tertiary deposits occur layers where the amount of lime is so high that the material might be classed as a soft, chalky limestone. In some places the lime has formed a cement, giving rise to hard layers which resemble mortar, hence the name "Mortar beds" for the portions of the Tertiary where these occur. These very calcareous layers are usually only a few feet thick and do not cover much of the surface. In the escarpment in the southeastern part of the survey they form a considerable area of rough, broken country. East of Pratt occur layers of the white calcareous material which give rise to the Clark series of soils.

Over most of the northern part of the area the surface material consists of a gray to pale yellowish silt, which is referred by Darton to the loess of Pleistocene age and of æolian origin. It is not very different from the silty material of the Tertiary and the line of

separation between the soils is very arbitrary. The soil is mapped as the Colby silt loam.

In some sections of the area, especially along the south side of the Arkansas River, the wind has blown the sand into "sandhills." Darton considers that the sand has been derived from the alluvial flats along the river and blown out by the prevailing winds, of which the stronger are from the northwest. While some of the sand has undoubtedly come from this source, most of it is believed to have been derived from outcrops of sandy strata in the Tertiary. In some places the sand is mapped as Dunesand, but in others the percentage of fine material is sufficient to class it with the Pratt loamy sand or Richfield sandy loam.

The most recent geological formation, except some of the sandhills, is the alluvial material along the streams, which is being added to by every overflow. Differences in the character of the alluvium has resulted in the formation of several series of alluvial soils, including the Laurel, Miller, Arkansas, and Lincoln.

RELATION OF SOILS TO CLIMATE.

Through the action of certain processes or agencies, the material comprising these different geological formations has been converted into true soil. The most important processes involved in this transformation vary with the climate, especially with the amount of precipitation, and therefore soils formed under dissimilar climatic conditions will not have the same characteristics, although derived from the same kind of material.

In the chapter on climate it was shown that the average precipitation in extreme western Kansas is less than 20 inches, and the area is classed as semiarid. This amount of rainfall has not been sufficient to leach out much of the soluble material, so that the soils are practically all high in lime and other soluble matter. This is especially true of the subsoils of the heavier lands, which are seldom if ever wet to a depth of 3 feet below the surface. Coming eastward, the rainfall increases, more leaching has taken place and the zone of weathering is deeper. The difference in the soils between the eastern and western portions is sufficient to justify their separation into different series, although the line of division is entirely arbitrary.

As the material from which the soils are derived was brought from more arid regions farther west and has undergone little leaching since its deposition, the soils of this area are in general rich in soluble mineral matter, as compared with the humid parts of the country. In a few places in the river valleys, where irrigation has been practiced or where the water table is near the surface, an excessive accumulation of soluble salts has taken place, and in such locations care should be exercised to prevent damage from this cause.

The presence of a comparatively large amount of soluble material, especially lime, has a very important influence upon the organic portion of the soil. Combined with proper moisture conditions, they favor the accumulation of a large amount of humus, to which is due the dark color so pleasing to the farmers and so characteristic of prairie soils. As the eastern portion of the area has a greater rainfall, the soils here have in general a somewhat larger amount of humus and a darker color than in the western part. In fact, near the Colorado line the percentage is not very high and the soils approach in character those of the arid regions proper. In general, however, it may be said that the soils of this section are fairly well supplied with organic matter, those of a sandy texture having the least amount.

CLASSIFICATION.

Differences in the processes of weathering and in the character of the underlying rocks have resulted in the formation of a great variety of soils, related to each other in various ways. In order to bring out these relations, some means of classification has to be adopted.

According to differences in the agency or method of deposition of the underlying formations the soils may be divided into five groups: (1) Those derived from sandstones and shales; (2) those formed from limestones; (3) those derived from unconsolidated or slightly consolidated water-laid deposits; (4) those formed from wind-laid deposits; and (5) alluvial soils, or material laid down as actual soil. The line of division between these classes are not sharply drawn, and in some cases more than one agency has been concerned.

Further subdivision of each of these groups can be made. Where the soils are similar in all their general characteristics except texture the types have been included in a series and given the same place name. A complete series would represent a gradation from sand to clay, but usually only a few members are present, and in some instances only one member of a series or a miscellaneous type is found. A combination of the series or place name with that of the class or texture designation constitutes the type. The general characteristics of the different series with a more detailed description of the individual types will be given.

In a reconnoissance it is not possible to make as fine separations as in a detailed survey, and the material mapped as a type must necessarily often include wider variations in character, and many small areas of other types, while sometimes two or more types have to be shown in one color on the map. The table on the following page shows the classification and area of the different soils mapped in this survey.

Classification and area of the different soils mapped in this survey.

Soil groups and types.	Total area of type.	Proportion of total area.
	Acres.	*Per cent.*
Soils from sandstones and shales:		
Summit series—Summit silt loam and silty clay loam	3,854,592	15.1
Vernon series—Vernon silt loam	578,304	2.3
Englewood series—		
Englewood fine sandy loam	64,512	.2
Englewood silt loam	145,152	.6
Miscellaneous—Belvidere silt loam	23,040	.1
Soils from limestones:		
Clark series—		
Clark stony loam	161,280	.6
Clark sandy loams and loams	46,080	.2
Miscellaneous—Benton stony loam	677,376	2.7
Soils from unconsolidated water-laid deposits:		
Pratt series—		
Pratt loamy sand	400,896	1.6
Pratt gravelly sandy loam and coarse sandy loam	449,280	1.8
Pratt sandy loam	490,752	1.9
Pratt loam	82,944	.3
Greensburg series—		
Greensburg sandy loam	76,032	.3
Greensburg silt loam and silty clay loam	698,112	2.7
Richfield series—		
Richfield sands and sandy loams	1,562,112	6.1
Richfield loam	230,400	.9
Richfield silt loam	3,375,360	13.2
Richfield silty clay loam	198,144	.8
Miscellaneous—		
Hamilton soils	237,312	.9
Russell sandy loam	82,944	.3
Ashland silt loam	13,824	.1
Fowler silty clay loam	41,472	.1
Protection loam	9,216	.1
Lacustrine soils:		
Scott series—		
Scott silt loam	6,912	.1
Scott silty clay loam	62,208	.2
Hoisington series—Hoisington silty clay loam and clay	39,168	.1
Soils from wind-laid deposits.		
Colby series—Colby silt loam	9,156,096	35.8
Miscellaneous—		
Canyon loam	714,240	2.8
Amarillo sands	41,472	.1
Dunesand	670,464	2.5
Alluvial soils:		
Laurel series—Types undifferentiated	152,064	.6
Arkansas series—Arkansas fine sandy loam	80,640	.3
Lincoln series—Types undifferentiated	983,808	3.9
Miller series—		
Miller sands	9,216	.1
Miller silt loam	43,776	.2
Miscellaneous—		
Meadow	73,728	.3
Salty marsh	41,472	.1
Total	25,574,400	

SOILS FROM SANDSTONES AND SHALES.

SUMMIT SERIES.

In the Summit series are grouped the silty upland soils derived from Cretaceous shales. As a rule the original rocks are calcareous sandstones or shales having a white to light-brown color. They first break up into a light-colored silty material resembling the loess soils very closely, but where further weathering of the soil has taken place they are changed to dark-gray silt loams and silty clay loams. The close resemblance of these weathered products to the soils derived from the loess makes their separation extremely difficult where they come in contact. It is only by the appearance of the soils in deep cuts that they can be distinguished. Where such exposures were not found an arbitrary line was drawn. This condition prevailed in the southern part of the area of the Summit soils, where they pass gradually into the Richfield silt loam, and in some places on the contact with the Colby silt loam.

In this area only one separation has been made, though in more detailed surveys the silt loams and silty clay loams which represent different stages of weathering might be indicated on the maps.

SUMMIT SILT LOAM AND SILTY CLAY LOAM.

Description.—The soil of the Summit silt loam and silty clay loam consists of a dark-gray to very dark-brown silty loam to silty clay loam. The coarser grades of sand are rarely present in any quantity,[1] but the very fine sand ranges from 5 to 10 per cent, and the silt content ranges from 70 to 80 per cent. The percentage of clay ranges from 10 to 20 per cent, sufficient, when combined with the very fine silt, to give the soil its heavier character. The dark color of the soil depends upon the extent of weathering, but more upon the amount of humus present. In depth the soil may range from 8 to 18 inches, but 12 inches is perhaps the average depth. The top soil is naturally shallower along the watercourses where erosion has been more rapid. The subsoil is a heavy, compact silty clay loam or clay, which becomes more friable below 3 feet. It usually contains about as much silt as the soil, but the clay content is higher.

The Summit silt loam and silty clay loam when in sod is tough and hard to break, but when broken with proper regard to moisture conditions it works up into a mellow seed bed. When plowed too wet or too dry it is liable to clod and to be very difficult to handle.

As might be expected in a soil covering so wide an area, numerous phases occur. One of these is extensive in the southern part of the area occupied by this type, and occurs in smaller spots throughout

[1] Soil Survey of the Russell Area, Kansas, p. 9.

the other portions. It is a phase lighter in color and often in texture than the true type. Toward the south, as in Barton County, it is due to a difference in the original rock, while in most other places it may be due to a thin covering of loess, which has influenced the texture.

Where the heavy subsoil is very hard and compact, it is locally known as "hardpan." In some places these locations, though small, give considerable trouble to the farmer. They are most common in the southeastern part of the area of the type, particularly in Rush and Ness Counties. This hardpan seems to be due to a compact structure of the clay rather than to lime or iron cementation.

The type resembles the loess soils in many particulars, and the boundary between them is in many places an arbitrary one. In the northern part of the State, where the streams have cut deeply and exposed good sections, the loess may be easily traced where it lies over the stratified rocks, but toward the south, where the superficial covering of soil is much deeper and few exposures are available for study, it is a matter of much more difficulty to distinguish between the different silty types, which resemble each other so closely near the surface. The deep subsoil of the Summit silty clay loam distinguishes it from the loess types, as below 3 feet it is more compact, and has a slightly drab color, as compared with the lighter textured yellow loess.

The lime content of the type is much less than that of the loess types, amounting in the greater part of the samples analyzed to less than one-half of 1 per cent. It is probable that the lime content depends upon the amount contained in the original rock.

Location.—The Summit silt loam and silty clay loam occur along the eastern part of the area and extend well toward the center of the area near the Arkansas River. The soils cover a large part of Smith, Russell, Osborne, Barton, Rush, and Ness, and portions of Hodgeman, Pawnee, Ellis, and Phillips Counties. Toward the east the plains are well covered by this type, but nearer the areas of loess soils it occurs as ragged, irregular areas along stream courses.

Topography.—The type near the borders of the loess occurs in the valleys where the exposed calcareous shales have weathered. As the loess thins out, the strips of this soil widen, until the whole divides are covered. The stream valleys may be sharply rolling, and drainage channels have dissected the divides until they are at least gently rolling. Very little of the type is so rough as to be unsuited to agriculture.

Origin.—The type is derived in different parts of the area from three groups of Cretaceous formations, known, respectively, beginning with the lowest, as the Dakota sandstone, the Benton group, and the Niobrara formation. The Dakota sandstone from which the southeastern portion of the type is derived is a light buff colored, very

fine grained sandstone which breaks down under the influence of weathering to a light-colored silt scarcely to be distinguished from the loess. It weathers slowly into a heavier soil. The predominant stones in both the Benton and the Niobrara are fine-grained calcareous sandstones and shales. All are light colored and weather into a soil heavier and darker than those from the Dakota, but in the western section the loess soils are also heavier when they come in contact, and the same difficulty is experienced in drawing a boundary between them. As far as texture and crop adaptation is concerned, there is little difference between them, and they are separated on the basis of origin.

Native vegetation.—The native vegetation consists of buffalo grass (*Bouteloua olygostachya*) and other small-leaved grasses. In ordinary seasons these grasses do not grow high enough to cut for hay, but for pasture they are unexcelled. No trees or shrubbery are found on the uplands of this type.

Utilization.—The Summit silt loam and silty clay loam are well adapted to all upland crops, and farming is safe and profitable on all parts of the type. Wheat, corn, and the sorghums do well, and acreage yields are higher than on the loess types, because of the greater rainfall toward the eastern part of the area.

As on all other types in the State where rain in some years is deficient, there is a wide range between the best and the poorest crops. With wheat the range is from total failure to 40 bushels per acre, the average crop in different parts of the type being from 13 to 15 bushels. The average for corn ranges from 20 to 25 bushels.

Vernon Series.

The Vernon series includes the upland soils of a reddish color that have been derived from the weathering of the Permian Red Beds. In this area only one member of the series, a silt loam, has been mapped, but numerous areas of the sand occur too small to be mapped.

This series is widely distributed over portions of Oklahoma, Texas, and other States, and wherever the topography is not too rough, it is a very productive soil. In many places, however, as in this area, erosion has cut rapidly into the soft, partly soluble shales and the country is so cut up that the agricultural value of the types as a whole is seriously impaired.

VERNON SILT LOAM.

Description.—The soil of the Vernon silt loam to a depth of 12 inches is a mellow, friable brownish-red to light-red silt loam, carrying a small percentage of fine sand. The subsoil of the type is

similar, except that it is a little lighter in color, owing to the smaller amount of organic matter and to less weathering of the soil-forming material. On the steeper slopes the red color is typically developed and there is no sharp line of demarcation between the soil and subsoil. In such areas the underlying parent rock is often found at a depth of less than 3 feet, because the removal of the soil has gone on nearly as fast as the weathering of the rock. The color of the soil varies slightly with the topography; on the gently rolling areas the soil is darker and grades into the Ashland silt loam, from which it differs only in color. Small areas of the Ashland silt loam are found throughout this type where conditions are favorable for the accumulation of organic matter and the deeper weathering of the rock.

In the southeastern part of Barber County, in the vicinity of Hazelton, the Vernon and Ashland silt loams are so mixed that it was impossible to separate them in this survey. In general the brown surface soil is characteristic of the gently sloping tops of the divides between the streams, while the red surface soil is characteristic of the steeper slopes toward the streams and the rough broken portions of the type. Another variation is the dull red color and the clodded nature of the soil near the outcrops of gypsum.

The soil mapped as Vernon silt loam in eastern Barber County, near Sharon, consists really of reworked soils of the Vernon series and sandy material from the Tertiary to the north and is a brown to reddish-brown loam to a depth of 16 inches, containing a considerable percentage of coarse sand. The subsoil is a reddish-brown loam becoming redder and more silty with depth.

On the lower slopes adjacent to Medicine Lodge River and the larger streams small amounts of gravel are present, scattered over the surface. This has been brought down before the streams had cut down to their present level. Gravel is also found on other portions of the type where it joins the areas of Pratt gravelly sandy loam.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Vernon silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
25380	Soil	0.0	0.8	0.5	0.5	12.2	75.5	10.3
25381	Subsoil	.4	.8	.4	.5	19.1	70.5	8.3

Location.—An extensive continuous area of the Vernon silt loam occupies southeastern Comanche and the greater part of Barber

County, where the Salt Fork, Medicine Lodge, and their tributaries have cut through and removed the Tertiary material of the plains. Irregular isolated areas occur in southeastern Meade, southern Clark, and southeastern Comanche Counties, in the Valley of the Cimarron River.

Topography.—The topography of the type is gently rolling in southeastern Barber and rolling to broken and rough over the remainder of the type. In southeastern Comanche the country has the appearance of a gently rolling table land, interrupted by numerous deeply eroded draws, which become wider and deeper as they approach the Salt Fork. (See Pl. XV, fig. 1.) Farther east, in western Barber, all of the Tertiary material has been removed except on the very top of the divide between Salt Fork and Medicine Lodge Rivers. The other areas are on the steep slopes or rough tops of the red buttes over which the Tertiary material was deposited and later removed by erosion. There are many typical flat-topped buttes capped by gypsum-bearing shales or by hard layers of red sandstone.

Drainage.—The drainage is excessive over the largest part of the type and numerous streams have their source in the springs that occur along the base of the Tertiary gravel overlying the Red Beds.

Origin.—The Vernon silt loam is a residual soil derived from the weathering of the fine-grained sandstones and shales of the Permian Red Beds. Irregular lenses of gypsum often outcrop along the bluffs in Barber County.

Native vegetation.—The native vegetation of the type consists of buffalo grass and bluestem, with a little salt grass on the lower slopes. Some sage and bunch grass is found in places. The red hills in Barber County formerly supported quite a growth of cedar and were for that reason locally known as Cedar Hills, but the cedar has been cut for posts.

Crops.—The farming land of this type is found as irregular areas on the more gentle slopes between the high bluffs and the streams which cut the lower slopes near Medicine Lodge and in the eastern part of Barber County. This is largely planted to wheat and corn. Wheat yields from 0 to 30 bushels, but 12 bushels is a fair average. A small acreage is devoted to oats. Corn is an uncertain crop, but the average yield is higher on this type than on the high plains, being about 25 bushels to the acre. Kafir and sorghum are grown to a large extent by the ranchers for winter feed. In the vicinity of Sharon, on the loamy phase of the type, the water table is near the surface and alfalfa can be profitably grown. From 3 to 5 cuttings are made each year. This phase seems to be a good apple soil and a few orchards are found usually in sheltered places along the streams.

Prices of land.—Grazing land in large tracts sells for $5 to $12 an acre, and the usual rent is about 50 cents an acre annually. The

price of farming land varies from $12 to $30 an acre, depending upon the amount of tillable land in the tract and the location with reference to markets. Alfalfa land in the vicinity of Sharon brings from $50 to $75 an acre, and that in southeastern part of Barber County finds a ready sale at $25 to $40 an acre.

Englewood Series.

The Englewood series has been established to include those soils which are associated with the soils of the Vernon series, but differ in their lack of the characteristic red color in the soil and present some differences in texture. It is probable that these variations have been brought about by deeper weathering of the Red Beds material and by the addition of material blown in or washed in from the higher lying types or left from a former covering of Tertiary material. The subsoils usually resemble those of the Vernon soils and in some cases it has the characteristic red color of the Vernon soils at 3 or 4 feet. Two types have been made in the Englewood series, a silt loam and a fine sandy loam. The latter is composed of material much reworked and has less of the Vernon characteristics than the silt loam.

Englewood fine sandy loam.

Description.—The Englewood fine sandy loam seems to be associated with the soils derived from the Permian Red Beds, and it may be a mixture between these and some of the sandy soils of other series. The top soil to a usual depth of 16 inches is a light reddish brown sandy loam. The sand content ranges in texture from very fine to medium, but the finer grades are usually greatly in excess. In some places the sand is in such relative abundance as to make the soil a sand rather than a sandy loam. This is the case in the more hilly positions of the type. The reddish tinge of the color is always present but is not so pronounced as to justify the classification of this type with the Vernon series. The subsoil is of similar texture, but the color becomes lighter and in some places redder with depth.

The soil is loose, almost incoherent, and easily tilled, but it does not blow away in windy seasons as badly as some of the other soils. On the other hand, this type does not have, in either soil or subsoil, the sticky feel characterizing the Pratt gravelly sandy loam, as the clay content is probably not so great.

Location and topography.—The type occupies a topography for the most part rolling, though small areas are nearly level. The contour would suggest wind formation, but while the surface has no doubt been modified some by this cause, there is no evidence of recent wind action or that the hills have been built up by the action of the wind.

The only large body of this soil is found in the southwestern part of Clark County, north of the Cimarron River, where it occurs as a long, irregular area, immediately above the Dunesand and below the soils of the Vernon series or those of the High Plains.

Origin.—The position of the type as well as the red color supports the theory that it is partly derived from the Red Beds of the Permian and that it contains a mixture of sand from some other formation. The source of the latter constituent is not easy to trace, as it may be either fine sand blown from the dunes or sandy material derived from the sandy strata of the Tertiary.

Utilization.—Only a small portion of the eastern end of the area covered by this type is cultivated, but over the western half farming is much more extensive. The type is well adapted to corn and kafir and the yields of these crops, especially the latter, are much more certain than that of the small grains. It is not so well adapted to wheat and some trouble is experience from the blowing away of the soil in the spring if precautions are not taken. East of Englewood, where the water table approaches the surface, good crops of alfalfa may be seen. Watermelons also do well in the better watered lands in this section.

ENGLEWOOD SILT LOAM.

Description.—The Englewood silt loam is a dark-brown to light-brown silt loam containing considerable very fine sand to a depth of 18 to 20 inches. From 18 to 36 inches it is a brown to reddish-brown silt loam containing some very fine sand. The subsoil becomes redder with increase in depth and grades into the Red Beds at varying depths, usually from 3 to 4 feet. In some places the red rock of these beds has weathered to a light-pinkish color, especially in prominent or exposed places, and there the subsoil is underlain by a pinkish disintegrated very fine sandstone. This soil overlies the Red Beds and is formed from them by the action of weathering and the addition of organic matter. The longer this soil is cultivated the browner it becomes and it is now much darker in color than it was before cultivation started. In many places it grades imperceptibly into the soil of the Vernon silt loam, so that the boundaries between the two soils are rather indefinite in some cases, although in other cases the distinction is quite marked, especially where a canyon occurs.

The sand is of such fine grade that it is scarcely perceptible, but there is quite a considerable amount of it in the soil. Some of the soil mapped in this type is a very fine sandy loam, but the two soils grade into each other and the difference is so slight that they were mapped as the same type.

The soil is slightly more loamy than the Vernon silt loam, and less friable. It occupies level to slightly rolling areas, but never occurs

as eroded land or sharp slopes, as in these places the Red Beds have not had time to weather sufficiently to produce it. The largest body of this soil occurs in Clark County, where there are large comparatively level areas extending across the county. It is also found in Comanche and Barber Counties, where it usually occurs as small level plateaus above the surrounding rough country. The soil is well drained. It is friable and easily cultivated and the large amount of sand contained makes it a good corn soil. It is not so good for corn as the red land, but is a better wheat soil. Where the land has not been cultivated it affords good pasture. The crops on this soil are wheat, corn, kafir, sorghum, and milo maize. Wheat yields, in good seasons, 20 to 22 bushels, although some yields are higher. Indian corn averages 15 bushels, although in a good year it may yield as high as 30 bushels. In order to be sure of a crop it would be well to plant part of the corn early and part late, and some farmers advise planting as late as in June. A large percentage of this type is under cultivation, although there are several large ranches in Clark County. The wheat should be drilled during September or the early part of October so as to enable it to get a start before cold weather sets in. This soil varies in value according to its location. Some land close to Ashland sells for $50 an acre, while land farther away sells for $20 and $30 an acre.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Englewood silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
25351	Soil	0.3	0.2	0.2	0.8	14.4	68.1	15.9
25352	Subsoil	.0	.2	.1	.5	15.1	59.0	25.0

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 25352 2.47 per cent.

MISCELLANEOUS.

BELVIDERE SILT LOAM.

Description.—This type consists of a grayish-yellow to brown silt loam to a depth of 10 to 14 inches, underlain by a grayish-yellow loose silt with flakes of shale. On the lower slopes the subsoil becomes darker and less weathered. The soil becomes hard and compact and cracks when dry. The underlying shale is often found within 3 feet. Flakes of grayish yellow and black shale fragments of anhydrite and fossiliferous limestone are common on the surface and throughout the type.

Location.—Only two areas of this type were mapped—one in the southeastern part of Kiowa County near Belvidere, the other in the southern part of Comanche, near the Oklahoma line. The type is rough and broken, and has many rock outcrops and deep erosions.

Origin.—The soil is composed of imperfectly weathered Kiowa shale of the Cretaceous, which consists of grayish-yellow shale underlain by black or bluish black shales and separated from the latter by a thin layer of fossiliferous limestone. Some Tertiary gravel is often found on the surface. North of Medicine Lodge River the type occupies the steep bluff and is chiefly outcrops of yellowish and black shale.

Utilization.—The native vegetation is a thin growth of buffalo grass. The type is too rough for farming and is used for grazing.

SOILS FROM LIMESTONES.

CLARK SERIES.

Around the edge of the High Plains in many places occur outcrops of cemented layers of the Tertiary. In some parts of the State it is a calcareous conglomerate mass, the "Mortar beds" of earlier geologists.

The soils derived from this material have been mapped as the Clark series and two separations have been made—a stony loam and the sandy loams and loams.

CLARK STONY LOAM.

Description.—An extensive tract of rough stony land north and northwest of Ashland has been mapped as the Clark stony loam. It is not uniformly rough, but contains strips of tillable land on the slopes and in the valleys. The arable soil varies widely, depending upon the advancement of weathering in the rock and the rate at which the surface soil has been removed by erosion. The usual soil is a light to dark brown silt loam, underlain by a lighter colored silt loam, containing more or less soft white calcareous rock. There may be limestone fragments of all sizes and shapes interspersed through both soil and subsoil or scattered over the surface. The top soil may in places be as deep as 18 inches, but more often it is not over 6 inches. The deep-brown well-weathered soil is found only in the level less-eroded areas. Where the country is more eroded, the calcareous rock outcrops and appears as blocks and ledges. By erosion or by the shrinking of the underlying strata, blocks and fragments of the rock have fallen and obstructed the hillsides. On the slopes and tops of sharply rolling hills there is little or no surface soil, only a mass of partly disintegrated calcareous material. In the

northern part of the area mapped with this type there are extensive outcrops of the calcareous shales and limestones, and there is practically none of it that can be cultivated. Near the southern edge of the type the Red Beds are exposed in cuts and valleys, and the roughness of much of the country is here due to removal in solution of the salt and gypsum beds of the Permian and the breaking in of the overlying strata.

In the southern part of Clark County there is a nearly level area, over which the surface soil averages 12 to 18 inches in depth, but the limestone fragments are usually present on the surface.

Location.—This soil is found in Clark and Meade Counties. In Clark County it occurs as a rather irregular but continuous body lying between the red soils of the Permian and the High Plains. In Meade County the area continues over from Clark County, but it becomes even more irregular in shape, following the headwaters of the small creeks tributary to Big Sandy Creek, and takes the form of borders of badly eroded land on the slopes or escarpments along the streams.

Origin.—The relatively small areas of the soil are formed by weathering from the calcareous rocks of the Mortar Beds and the different depths of soil represent the length of time that weathering of the rock has gone on undisturbed. Over a large part of the area of this type the soil has been washed from the hillsides as fast as it accumulates from the decomposition of the rock.

The whole area was probably once covered by the Plains Marl, but this has been removed, though probably influencing the soil in places.

Utilization.—Very little of the tillable land is now under cultivation. Most of it, occurring as it does in irregular areas among the stony hills, can be more profitably used for pasture. It supports a good growth of the best native pasture grasses, including buffalo, grama, bluestem, and bunch grasses.

The small level areas of the southern extremity of the area of the type are nearly all cultivated and give fair yields of wheat, corn, and the sorghums. In the western part of Clark the type is cultivated to some extent, but the greater part of it is better suited to grazing. The principal crops grown here are kafir and sorghum, which are used for winter feed.

CLARK SANDY LOAMS AND LOAMS.

Description.—Clark sandy loams and loams usually consist of a grayish-brown to dark-gray silt loam, usually containing some fine sand and varying from 6 to 24 inches in thickness. This is underlain by a light-gray to white soft calcareous rock. The soil sometimes contains fragments of calcareous material, and these are also scattered over the surface. The calcareous layer crops out at the surface

in various places generally as small ridges or knolls. Some areas consist of 0 to 12 inches of a grayish loam to grayish silt loam, containing some white sand and with nodules of calcareous material scattered over the surface. From 12 to 24 inches it is a grayish-brown to grayish-yellow, sticky sandy loam to sandy clay, containing a large amount of calcareous material mostly in a finely divided state. This grades at 24 inches into the pure grayish-white calcareous material.

These areas occur in depressions and usually in proximity to a sandy silt. Where sand has blown over the calcareous material or been left from an overlying sandy layer, the surface soil is a sandy loam or loamy sand.

Location.—These soils are found in the eastern parts of Pratt and Stafford Counties, where the elevation is less than that of the country to the west. There is one area, also, in Comanche County near Coldwater. It is usually found on the slopes of hills, but sometimes on fairly level spots. It also covers many knolls which are too small to map. The surface features insure good drainage except in the heavier phase found in the depressions, which is poorly drained.

Origin.—Clark sandy loams and loams are formed from the layer of Mortar Beds which underlies the plains and overlies the Tertiary gravel and sand in that section. In Pratt County this layer is probably about 30 feet in thickness. The Plains Marl that previously covered it has been eroded away. The surface soil has been weathered from the calcareous material and the varying thickness of the surface soil represents varying stages of weathering. The calcareous layer is of Tertiary. Where sand has blown over the calcareous layer weathering has not so far advanced. This calcareous layer slopes down to the west in Pratt County.

Utilization.—The crops grown on this soil are wheat and corn. Where the surface soil is thick enough to favor it, fair yields of wheat are obtained. It does not seem well adapted to corn and very low yields are obtained. Only a small part of the land is farmed, the remainder being used for grazing.

Miscellaneous.

Benton stony loam.

Description.—The term Benton stony loam is applied to the areas of rough land adjacent to streams which have cut their channels into the shales and limestones of the Benton and Niobrara groups and where the weathered products of these rocks have entered into the composition of the soil.

The Benton stony loam occurs along nearly every creek in the eastern part of the area north of the Arkansas River, and it follows some of the more deeply cut stream channels nearly to the western

boundary of the State. The largest bodies of the type lie along the slopes of the Solomon and the Saline. They are inclosed by areas of the Summit silt loam and silty clay loam, but streams like the Smoky Hill River, that have cut deeply into the loess, have areas of the Benton stony loam at intervals to the west part of the State.

The type was mapped in the soil survey of the Russell area, Kans., as the Benton loam, and the description given in that report is representative of the soil in other parts of the State. It was there described as follows:

The surface soil of the Benton loam, ranging in depth from 3 to 12 inches, is a light-brown to grayish silty loam, often having small argillaceous shale and limestone fragments scattered through it and lying on the surface. The soil grades quickly into a light-colored subsoil, which is almost wholly made up of partially decomposed shale, mingled with which occurs a small quantity of limestone fragments in various stages of degradation. At a depth of from 25 to 36 inches the rotten shale and limestone in the subsoil often appear as soft chalky particles, causing the color to become lighter. Owing to its general porosity and the chalky nature, the subsoil retains and gives up but little moisture for the growth of crops.

Location.—The Benton loam is found where the country is cut by small streams and draws. It follows the immediate course of these very closely and extends both along their steep banks and usually some distance back upon the ridges, which slope gently toward them.

The topography is naturally rough and broken, and the general appearance of the country is that of a gently sloping table-land, intersected by a great number of deep erosions, which gradually deepen and widen as they near the rivers, their banks becoming almost perpendicular walls from 50 to 75 feet high. These draws afford excellent drainage, but as they have deepened and widened the ridges between have decreased in extent and the upper soil has become eroded and washed down into them. The location of this soil is not such as to allow it to conserve moisture and withstand drought, as water falling on the ridges soon finds its way into the neighboring draws. On the more level ridges the soil is deeper, but on the steeper slopes near the draws it is often so shallow as to expose the white shale and limestone which underlie it. Thus small areas that have the characteristics of a stony loam are sometimes encountered, but these are not of sufficient extent nor of frequent enough occurrence to be recognized as a distinct soil type of the area.

Origin.—The Benton loam is a residual soil, being derived from the fossiliferous layers of shale and limestone in the upper series of the Benton group, but in a more imperfect state of decomposition than that of the main upland type. These shale beds and limestone strata disintegrate rapidly where the topography is such as to expose them to the action of the atmospheric agencies, but erosion has prevented the soil from accumulating to any great depth.

Utilization.—The most of the territory covered by this soil type is devoted exclusively to pasture, an abundance of native grasses being found on it. At the present time the production of cultivated crops is attempted only in a few instances, as the other types offer so many more advantages for cultivation. On a few of the more level slopes kafir and sorghum have been cutivated with success. The type is well adapted to stock raising, as the numerous draws furnish protection during the winter, and the grass on the slopes insures pasturage the greater part of the year.

SOILS FROM UNCONSOLIDATED WATER-LAID DEPOSITS.

PRATT SERIES.

In the eastern extension of the Tertiary formations the materials have a distinctly reddish tinge, which has persisted in the soils formed from them. The soils so characterized have been called the Pratt series. Besides the color, which in all the members is a slightly reddish brown, there are common properties of texture. The sands are composed to a large extent of feldspars and minerals other than quartz, and wherever the sandy soils have been exposed to weathering they have become more loamy in texture. This is indicated by the sticky character of the very sandy soils, where weathering has been undisturbed. In this series the soils distinct and extensive enough to map are a loamy sand, a gravelly sandy loam and coarse sandy loam, a sandy loam, and a loam.

PRATT LOAMY SAND.

Description.—The Pratt loamy sand is a reddish-yellow or brown loamy sand, rather loose in structure, to a depth of 18 inches, grading into a reddish-colored loamy sand that is slightly heavier in texture and contains some clay, which gives it a sticky feel and makes it more compact than the surface soil. The subsoil becomes heavier and more compact and sticky with increase in depth. This soil is easily cultivated, but unless great care is taken it blows badly when loosened by the plow.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Pratt loamy sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
25372	Soil	0.9	18.7	24.0	36.5	9.9	3.8	6.3
25373	Subsoil	.6	24.3	28.5	29.2	8.6	3.0	6.1

Location.—The type is found in the southeastern part of the area and occurs as bodies of greatly varying size, south of the Arkansas River in Kiowa, Edwards, Barton, Stafford, and Pratt Counties.

Topography.—The surface varies from level to rolling and hilly, the larger part of it having a sand-dune topography. Some of the areas are very nearly sand dunes, but few or none of them are now in motion. It is a well-drained soil, but has a great moisture holding capacity and even in the driest weather contains a large amount

of moisture, this being due in a large measure to the sticky nature of the subsoil.

This soil varies somewhat in the size of the soil grains. In Stafford County it is finer in texture than elsewhere; almost a loamy fine sand. The tendency seems to be to become lighter in texture with progression eastward. Heavier spots of clay loam texture and brown color are found in small depressions throughout the type and probably represent fine material deposited by water action. In some places the loamy sand grades imperceptibly into the Dunesand. Some of this type was originally wind-blown sand, but through weathering and the addition of organic matter it has gained a loamy texture and is therefore classed as loamy sand.

Origin.—This soil was probably formed from the Tertiary material that underlay the plains, the plains material having been eroded away. A considerable area of the Tertiary material did not include a large proportion of gravel, and the light and loose texture of the soil caused it to be blown away, thus giving rise to the sand-dune topography. It still blows to some extent every year.

Native vegetation.—The grasses found on the loamy sand are bluestem, sage, bunch-grass, tickle-grass, and a small amount of buffalo-grass.

Utilization.—The crops grown are corn, sorghum, and wheat. Corn does better on this soil than on the hard lands and gives a crop nearly every year, even when there is little or no crop on the hard lands. This is due to the great amount of moisture that the soil holds. An average corn crop is about 20 bushels. The corn is all sown with a drill and seldom receives any cultivation, although it would be well to cultivate it after the summer rains. The time of planting depends on the season. Some seasons an early planted crop gives better yield and in others a late planted crop does best. In general, however, the best results seem to be obtained on the very sandy soils by late planting, as the hot winds do not cause so much damage and the soil stands the drought well. Wheat does not do so well as it does on the hard lands and is not a sure crop. When sown to wheat the soil is liable to blow badly, and the seed is often blown out of the ground. The average yield is 4 to 10 bushels. Wheat should be planted early—as early as September 1—so that it may make good growth before the ground gets too cold.

Grazing the small grains assists in compacting the soil, but they should not be pastured too late in the spring. Peaches do well but are small. Grapes do fairly well. Melons do well, and give the largest yields on sod. Vegetables have to be irrigated.

This soil varies considerable in value; some of it brings as little as $10 an acre.

PRATT GRAVELLY SANDY LOAM AND COARSE SANDY LOAM.

Description.—The Pratt gravelly sandy loam and coarse sandy loam, to a depth of 14 to 18 inches, is a loose yellowish-brown sandy loam, the sand content being of all grades, with the medium and coarse grades in the greatest abundance. The subsoil consists of a brownish coarse sandy loam or loamy sand, with a considerable percentage of medium and coarse gravel. The subsoil usually becomes looser in structure with increase in depth. A characteristic feature of the subsoil is the clay content, which though relatively small is of such quality that it imparts a sticky nature to it, making it so adhesive that it is compressed into a compact mass when squeezed in the hand. The sand and gravel of both soil and subsoil are composed of quartz and feldspar, but the grains are not clean, as the fine, sticky clay gives even the soil a more loamy character. The surface soil is loose and plows as easily as the sandy land, though it clods slightly and is not drifted by the wind as readily as the more sandy soils.

For a few miles east of Coldwater, in Comanche County, the type has a slightly reddish brown color and the medium to coarse gravel found in a large portion of the type is lacking. Where the soil has a considerable percentage of organic matter the color is a dark brown. The subsoil of this phase is also darker in color and has the stickiness that is characteristic of other portions of the type. This phase has a topography that distinguishes it from the other portions of the type, its present surface features being due to wind action, which probably accounts for the absence of gravel.

The heavy material of the Greensburg silt loam underlies a strip of this type, extending from the main body near Mule Creek and connecting with the area of the same soil in central and southern Comanche. This underlying heavy stratum is rarely within 3 feet of the surface.

In the vicinity of Sharon, in eastern Barber, the soil is a loose yellowish-brown coarse sandy loam with little or no gravel. The subsoil is a slightly reddish-brown coarse sandy loam, with a little fine gravel, becoming more compact with depth.

In the Protection Valley, between Coldwater and Protection, another phase of the type is found. This consists of a dark-brown coarse sand to a depth of 15 inches, usually with a mantle of loose grayish sand. The subsoil is a loose, brownish coarse sandy loam, becoming heavier with depth and grading into a drab or brownish sandy clay at 34 inches, and underlain at still greater depth by a heavy black material, similar to the area of soil found east of Protection. This shows that the material from which the Pratt gravelly sandy loam is derived was deposited over the earlier heavier material.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Pratt gravelly sandy loam and coarse sandy loam:

Mechanical analyses of Pratt gravelly sandy loam and coarse sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
25370	Soil	2.3	28.4	22.1	20.9	7.3	5.7	12.9
25371	Subsoil	2.3	24.7	21.6	24.7	6.2	10.9	9.3

Location.—The Pratt gravelly sandy loam occupies a zone on the slopes between the level of the High Plains and the soils of the Red Beds and other types of the valleys. It occurs in extremely irregular areas in the southeastern part of the area, bordering Sandy, Cavalry, Nescatunga, and Mule Creeks in Comanche County, the Salt Fork in Barber County, and the tributaries of the Medicine Lodge in Barber, Kiowa, and Pratt Counties, and the Ninnescah in Pratt County. It is also found in narrow strips along Crooked Creek and Cimarron River in Meade County.

Topography.—There are two main types of topography, the rolling to broken occurring on the shorter slopes toward the streams and the gently rolling country which may be seen in the central part of Comanche County around Coldwater and near Sharon in Barber County. The drainage is excessive over a large part of the type, on account of the loose, porous nature of the soil and the rather steep slopes which permit a rapid run-off of the rainfall, but on the more level portions moisture is well retained.

Origin.—These soils represent the weathered product of the gravelly sandy stratum at the base of the Tertiary mixed in some places with colluvial material from the higher lands. There has also been some shifting of the sandier material by wind action and the differences in sand content in various parts are due to this cause.

Native vegetation.—The native vegetation is similar to that of the other loose sandy soils of the areas, consisting of sage and bunch-grass, bluestem, and some buffalo and grama grass. The yucca is occasionally seen on the sandier bodies.

Utilization.—A large proportion of the type is too rough to be farmed and is utilized for grazing. Small fields throughout the ranching country are planted to forage crops, such as milo maize, and with good results except in prolonged drought. On the more level portions near Coldwater the type is farmed and good yields of small grains, corn, and the sorghums are secured in favorable seasons. Near Sharon, where the water table is relatively near the surface, alfalfa does well and portions of the Protection Valley are fair alfalfa land.

PRATT SANDY LOAM.

Description.—The soil of the Pratt sandy loam is a slightly reddish brown medium to fine sandy loam with a depth of from 20 to 24 inches. The subsoil is a lighter reddish brown and contains more sand which is coarser in texture than that of the surface soil, becoming redder with increase in depth. The subsoil contains some clay, which makes it more compact and gives it a slightly sticky nature. This clay, which is derived by weathering from the feldspar constituent of the sand, increases with depth and makes the soil more compact.

South of the Arkansas River, in Edwards County, the subsoil is somewhat heavier and of a reddish-yellow color. Where there are sand dunes through this type, heavier spots are found in the depressions and probably represent the material deposited by washing from the surrounding higher lands.

Location.—The Pratt sandy loam lies south of the Arkansas River, except for one small area in Ford County. The greater proportion of the type is in two irregular bodies, which wind around areas of heavier soils in Edwards, Stafford, Pratt, and Kiowa Counties. There are also detached bodies in Ford and Meade Counties.

Origin.—The origin and process of formation of this soil is similar to that of the Pratt loamy sand, except that it is less influenced by wind action. It was probably formed from the layer of Tertiary that underlies the Plains Marl, after the latter had been eroded away. The topography has in places been modified by wind action.

Utilization.—Most of the type is farmed. The crops grown are wheat, corn, kafir, and sorghum. Wheat yields 18 to 20 bushels, although, in some places, under careful cultivation, larger yields are secured. In dry seasons the yields are very much less. Kafir yields 15 to 20 bushels, and sorghum 20 bushels. In good years corn yields 30 bushels. Kafir is best to cut for feed, but sorghum is more profitably grown for seed, which brings $1 or more a bushel.

PRATT LOAM.

Description.—The Pratt loam is quite variable and ranges from a silt loam to a sandy loam. The typical loam is brown in color and contains considerable silt to a depth of 18 inches. From 18 to 36 inches it is a reddish-brown, rather sticky sandy loam, grading into a more pronounced reddish color with increase in depth. The subsoil sometimes contains a small amount of fine gravel, which then gives it a looser texture. Sometimes the subsoil becomes very compact with increase in depth, but this variation is seldom found, the greater part of the type having a light subsoil. In the northeastern part of Pratt County this soil, from the surface to a depth of 10 or 12

inches, is a brown loam which in low spots is quite silty and on higher ridges somewhat sandy. From 12 to 24 inches it is a light-brown to yellowish-brown sticky loam which at 24 inches grades into a yellowish-brown to reddish-brown sticky loam or heavy sandy loam. The distinguishing feature of the type is the reddish tinge of the subsoil. This soil is easily cultivated, and the absence of any hardpan layer, such as occurs in the Greensburg soils, makes deep plowing easy.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of this type:

Mechanical analyses of Pratt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
25367	Soil	0.8	7.2	11.4	26.6	13.1	21.7	19.2
25368	Subsoil	.8	8.1	13.7	29.9	7.7	22.1	17.1
25369	Lower subsoil.	.8	7.9	13.7	30.9	12.5	18.4	15.6

Location.—The Pratt loam is found in the central and northeastern parts of Pratt County, in the northeastern part of Barber County, and in the southern part of Stafford County. The topography is generally rolling and the type often occurs on slopes of hills. One area in the southern part of Stafford County is comparatively level. In this area the sand contained in the soil is coarse. The gravel in the subsoil and also the gravel layer which underlies most of the type makes the drainage very good. This type is derived from a layer overlying the sandy and gravelly material which gives rise to the sandy members of the series. This layer underlies the silty formation which gives rise to the Greensburg soils.

Utilization.—This is a good wheat land and gives an average of about 16 bushels per acre. It is also a good soil for corn, kafir, and sorghum, although not so good for corn as the more sandy soils. Yields of 10 to 12 bushels per acre are secured. Most of the wheat is listed, and where corn has been planted it is frequently drilled in between the rows of corn. It would probably increase the wheat yield to prepare the seed bed occasionally by plowing.

Greensburg Series.

Above the material that gives rise to the Pratt series occurs a yellow silty deposit, from which has weathered a series of soils called the Greensburg series. This series differs from the Pratt, on the one hand, in the absence of the reddish color and from the Richfield series. on the other, in the lack of the white calcareous mottlings and

the smaller percentage of lime. Like the Richfield silt loam the Greensburg silt loam and silty clay loam have been derived from the Tertiary formation commonly called the Plains Marl, and it may be regarded as the same material more deeply weathered and leached. The change produced by these agencies is so gradual that the indication of the boundary between the two on the map was entirely arbitrary and might, with equal correctness, have been drawn 10 miles or more from the position indicated.

GREENSBURG SANDY LOAM.

Description.—The soil of the Greensburg sandy loam is rather varied in texture, but usually consists of a brown sandy loam, with a depth of 18 inches. Below this it grades into a brown silt loam, which becomes heavier in texture with increase in depth. In some places the surface soil is a heavy sandy loam. The subsoil also has phases which vary in texture in different places from a loam to a heavy sandy loam, but over the greater part of the area the subsoil is of the typical heavy silt loam.

Location.—This type is found only in Barton County, south of the Arkansas River. It is surrounded by other sandy soils that do not have the heavy subsoil and grades into them in places, but usually the line of separation is distinct.

Topography.—The topography is rolling, with hollows or depressions. The soil in these depressions is usually heavier in texture and represents fine material that has been deposited there. The rolling surface and the character of the subsoil give good drainage to the type.

Origin.—This soil has been formed by the deposition of sandy material over that of a heavier texture. For some reason, the Plains Marl in this section was not eroded away so as to expose the underlying layer of sand and gravel. Sand was blown over the Plains Marl either from the river or from the surrounding sandy soils and deposited as a thin layer, which has been mixed with some of the heavier subsoil to give it its loamy texture.

Utilization.—Most of this type is farmed, and it seems to be a good general purpose soil. The crops grown are wheat, corn, kafir, and some melons. It is a good corn soil and the average crop is profitable. In very good years 30 bushels of corn are made to the acre, but the average is much less.

This type varies in price according to location, the best of it bringing from $30 to $40 an acre. Some trouble is experienced from drifting, but this may be avoided if care is exercised in handling the land. It would be an excellent soil for dry farming if the dry mulch could safely be maintained for the retention of moisture, but

as wind damage will not permit the theoretical practice, the compromise of keeping the top soil granular and as fine as can safely be done must be resorted to.

GREENSBURG SILT LOAM AND SILTY CLAY LOAM.

Description.—Typically, the Greensburg silt loam and silty clay loam consist of a dark-brown nearly black, heavy silt loam or silty clay loam, which becomes slightly lighter in color and heavier in texture with increase in depth, and grades below 14 or 18 inches into a brown or yellowish-brown silty clay loam which is hard and tough when dry. Between 30 and 36 inches the subsoil again changes to a pale yellow compact heavy silt loam, which crumbles readily and becomes more friable with depth. This material continues to a depth of several feet.

On the more rolling areas the soil consists of a brown silt loam to a depth of 12 to 16 inches, underlain by a brown compact heavy silt loam or silty clay loam, which gives way at a depth of 24 inches to a yellowish-brown friable silt loam, differing from the corresponding layer of the Richfield silt loam in that it does not have white mottling and does not effervesce with acid.

Topography.—The heavier, deeper, and darker portions of the type occupy level to gently rolling country, while the lighter in color and texture cover the more sharply rolling topography. The difference in the soils is due to the more advanced weathering and the accumulation of large or smaller quantities of organic matter.

In the southern part of Comanche County the Greensburg silt loam rests immediately upon the Red Beds, as the sandy and gravelly strata of the lower Tertiary are absent. Here the type occupies the narrow divides between the deep, narrow draws cut into the Red Beds. Along the draws the red material seems to approach very near the surface, but a few rods back from these the red material is seldom found within 3 feet of the surface. The soil, to a depth of from 14 to 16 inches, is a light-brown to a dark-brown heavy silt loam, underlain by a brown heavy silt loam to a depth of 3 feet. An intermediate strip of Ashland silt loam lies between the Greensburg silt loam and the Vernon silt loam of the draws, but too narrow and irregular to map. A few small red knobs occur over these divides which have had some effect on the adjacent soils. Similar areas occur north of Bluff Creek, in Clark County, but at a lower elevation than the High Plains.

An area extending northeast from Lewis, in Edwards County, parallel to the Arkansas River, is included in this type. In this area the soil consists of a heavy brown or dark-brown silt loam or light silty clay loam, underlain either by a dark-brown or a slightly drab

silty clay loam. The depth to the sandy Tertiary stratum is from 4 to 8 feet. The soil in this region has been considerably modified by imperfect drainage and standing water, and is locally known as "gumbo."

Where the type is adjacent to the Pratt sandy loam, some sand is found in the first few inches of the soil or scattered over the surface, often as small mounds and ridges from 2 to 5 feet high. This is especially true of the areas in the vicinity of Macksville.

The area mapped in the eastern part of Stafford County is quite level, also darker and heavier than other portions of the type. It resembles very closely a soil derived from the weathering of shale, but the underlying Tertiary formations show that it is not. The subsoil of this body is very stiff and impervious, and is probably a silty clay in texture. The highest parts of the area from the town of Stafford east nearly to the county line have been modified by small ridges of sand and sandy loam.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Greensburg silt loam:

Mechanical analyses of Greensburg silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
25361	Soil	0.1	0.2	0.3	2.4	15.5	66.7	14.8
25362	Subsoil	.2	1.2	.9	4.4	13.9	63.4	15.8

Location.—The Greensburg silt loam occupies the highest part of the broad divide between the Arkansas and the Cimarron Rivers, extending eastward from a point a few miles east of Bucklin. In the southwestern part of Kiowa County the area occupied by the type forks and continues as three lobes. One lies between the south fork of the Ninnescah and the Medicine Lodge across central Kiowa and southern Pratt. Another extends as a very ragged area between Medicine Lodge and the Salt Fork of the Arkansas across northeast Comanche and western Barber. The latter lobe is narrow and the type occurs as irregular areas in the more level country, which has not yet been eroded to the Tertiary gravel, forming the surrounding Pratt gravelly sandy loam. The third lobe lies between the Salt Fork of the Arkansas and the Cimarron River across Comanche County to the Oklahoma line, and swings south into Oklahoma, but several narrow lobes of one divide extend into southwest Comanche County. This third lobe is apparently cut off from the main divide by the Pratt gravelly sandy loam, but the latter has drifted over a narrow connecting strip of Greensburg silt loam.

Other areas of the type occur in the sandy section south of the Arkansas in Edwards, Pawnee, and Stafford Counties. These areas were once portions of the main divide to the south, but were cut off by the removal of the upper and heavier portion of the Tertiary, thus exposing the sandy stratum below.

Topography.—The topographic features of the type have a wide variation. On the main divide it has the appearance of a broad, almost level prairie, which a few miles to the south breaks away abruptly and becomes rolling, until sufficient material has been eroded to expose the Tertiary sands and gravels from which the Pratt gravelly sandy loam has been derived.

Drainage is sufficient on the nearly level portion and excessive on the more rolling, while in the level areas drainage is retarded by the heavy subsoil and the lack of fall. With the exception of a part northeast of Lewis, the drainage is seldom sufficiently retarded to injure crops, yet it often delays early cultivation and planting.

Origin.—The Greensburg silt loam is the result of the weathering of a Tertiary formation similar to and of the same age as the Plains Marl with weathering so far advanced that the calcareous nature of the material has disappeared and the changes in color and texture have been brought about that distinguish this type from the Richfield silt loam.

Utilization.—The original vegetation of the type consisted of the native grasses of the plains. For miles the type is one broad wheat field, interrupted only by the roads and an occasional corn field. The yields vary widely with the seasons and the manner of cultivation. In ordinary good seasons the yields range from 10 to 40 bushels. A fair average for a series of years is probably about 12 bushels. Corn gives good yields in favorable seasons, but the long dry spells and the hot winds after the wheat harvest often injure or entirely destroy the crop; hence corn is a very uncertain crop and is rarely grown as a money crop. Very little success has followed the attempt to grow alfalfa on this soil. It make a promising start in the spring, but the summers are too dry. A few small fields in the vicinity of Stafford are giving good yields, but this is due to the more adequate water supply.

Kafir and sorghum are grown to a limited extent for fodder in the wheat country and a larger acreage in the rougher land, which is used for grazing. There is a small acreage devoted to oats and barley.

Richfield Series.

The Richfield series includes the grayish-brown to dark-brown soils derived from the Tertiary formations. As the original material varies widely in composition, the various soil types differ from one

another in texture and color, but each type is fairly uniform over its area. In texture the members cover a wide range, from a sand approaching the Dunesand to a heavy silty clay loam. They differ from the Pratt soils in the absence of the reddish color that is characteristic of that series.

The coarsest member of the type mapped as sands and sandy loams covers wider variations than any other type. It includes all sands and sandy loams, from a loose sand closely approaching that of the dunes to rather heavy sandy loams. In this type also was thrown the sandy loams and fine sandy loams in various parts of the area north of the Arkansas River mapped in the survey of the Garden City area as the Finney series. In a general survey it did not seem advisable to make the separation into another series for so slight differences.

The Richfield silt loam passes gradually into the Greensburg silt loam to the east, the difference between the two being based on the state of weathering of the Plains Marl and into the Colby silt loam on the north, which represents the weathered or partly weathered product of a more recently deposited loess.

RICHFIELD SANDS AND SANDY LOAMS.

Description.—There are included under this classification medium and fine sands and sandy loams which have been derived by weathering from the sandy strata of the Tertiary. They differ from materials of the same texture in the Pratt series in the absence of the reddish color that characterizes the latter group. Occurring as they do over a vast stretch of country, covering a varied topography, and subject to somewhat different climatic conditions, the Richfield sands and sandy loams have a considerable range in texture and color. It was found impracticable, however, in this survey, to separate the several types that might have been established in a more detailed survey. In the southwestern part of the State there are two distinct classes of the sandy land. One, a sandy loam, has the greater extent, occupying tracts of several square miles, bordering the sand dunes, or covering large areas where the very sandy Tertiary rocks outcrop. The other phase is a sand more limited in extent, which covers ridges and rolling land, bordering or surrounded by the Richfield silt loam or the Colby silt loam.

The soil of the sandy loam consists of 12 to 18 inches of medium to fine sandy loam, having a grayish to dark-brown color. There is sufficient silt or clay in the surface soil to make it slightly coherent when wet. The subsoil to a depth of 30 to 36 inches is a sandy loam so high in the finer particles that it is quite cohesive and in some places is somewhat impervious. As the depth increases the fine material becomes more abundant, and below 36 inches there may be a cal-

careous silty subsoil. It is likely that this is the case over a large part of the area of this phase, but in many localities it is several feet below the surface.

The soil of the fine sandy loams is darker in color and more compact than that of the sandy loams. The depth ranges from 6 to 10 inches. The subsoil, to a depth of 24 inches, is a yellowish-brown fine sandy loam, containing a small amount of medium sand. From 24 to 36 inches the subsoil in the northern part of the area becomes lighter in color but heavier in texture, while in the areas near the Arkansas River, the deeper subsoil becomes lighter yellow and sandier.

There are large areas of the Richfield sandy loams that cover low choppy hills of typical dune contour. The soil is likely to be loose and sandy to a greater depth on these, though it is not invariably so. The texture depends upon the amount of weathering that has taken place since the dunes became stationary. There is very little movement of the dunes by the wind at the present time, but care must be used in breaking land to prevent local "blow-outs."

North of the Arkansas River there are several areas of this type, but they are less extensive than those in the southern part of the State. In general, they may be divided into two classes—sandy loam and fine sandy loam.

The surface soil of the sands consists of gray to brown, medium to fine loamy sand, with a depth of 8 to 14 inches. It is generally loose and friable, but with sufficient organic matter and silt to make it coherent. The subsoil, to a depth of 24 inches, is a grayish-brown to yellowish-brown sandy loam. The sand content varies from fine to medium. From this depth it becomes lighter in color and often more sandy to a depth of more than 36 inches.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Richfield sands and sandy loams:

Mechanical analyses of Richfield sands and sandy loams.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
25359	Soil	3.1	10.2	13.3	23.8	23.9	18.2	7.9
25360	Subsoil	3.0	10.4	10.7	21.1	14.9	29.6	9.9

Location.—The Richfield sands and sandy loams are most extensively developed in the southwestern part of the State. South of and in the great bend of the Cimarron River they occupy a large proportion of the country, their uniformity being broken only by

the smaller areas of the other types of the same series. From the Cimarron, north to the Arkansas, there are irregular bands of the type several miles in width traversing the county in every direction. These bands mark the descent from the areas of undisturbed loess-covered plateaus. The largest areas of the type are in Morton, Stevens, and Seward Counties. The irregular-shaped areas traverse Stanton, Kearny, and Hamilton Counties. A continuous band borders the sandhills on the south and extends from the Colorado-Kansas line eastward almost to the town of Ford.

North of the Arkansas the bodies of the type are smaller. The sandy loam phase is found on numerous stream slopes within the vast area covered by the Colby silt loam. The most important development of the fine sandy loam is in Scott and Finney Counties.

Topography.—The topography of the types varies from nearly level to sharply rolling. Much of the country in Morton, Stevens, and Seward Counties has a typical sand-dune topography. These features are more pronounced in proximity to the Cimarron River, Bear Creek, and Sand Arroyos. The same topography prevails where this type comes in contact with the sand dunes, into which it gradually merges. In a portion of the southeastern part of Morton County there are considerable areas of nearly level, deep loamy sand. The type occupies a large part of the breaks along the Cimarron River. These are not usually very rough and a large proportion could be cultivated, except in the southeastern part of Seward County, where the country becomes exceedingly rough. In the latter vicinity the surface is dissected by many short drainage channels cut back into a calcareous sandstone, which erodes into a rough, broken land with characteristics of the "bad lands" of the Great Plains. This topography is developed to almost the same degree in Morton County along the Cimarron River.

The areas north of the Arkansas have the dune topography extensively developed. In some localities the hills have long been stationary and the dunelike contours have been modified by weathering and erosion. There are winding ridges irregular in height and outline, with narrower valleys of slightly heavier soil.

Origin.—The material of which the Richfield sands and sandy loams is composed was originally released by weathering from the arenaceous formations of the Tertiary, underlying the loess. Subsequent transportation by wind and water have reduced the size of the sand grains and shaped the surface features of the type. Of these agencies wind has been by far the most extensive in its action. There is much drifting of the sand by wind even at the present time. When the sand hills become stationary weathering immediately begins to work changes in the character of the soil. A large pro-

portion of the sand grains are feldspar and minerals other than quartz, and they break down readily and undergo chemical changes with comparative rapidity when exposed to weathering. While the original material varied in composition, the dune-shaped hills, which are now stationary, must owe their present loamy character to the decomposition of the sands once loose and incoherent.

Native vegetation.—The native vegetation of the type consists chiefly of bunch grass or sand grass, bluestem, and a small amount of buffalo and grama grass, Spanish dagger (yucca), and various weeds. Some sage is found on sandier areas. The better quality grasses, such as buffalo and grama, appear on the less sandy areas of the type. The Spanish dagger seems to be well adapted to the sandy loam ridges and other areas of sandy loam rather than to the more sandy phase of the type. (Pl. XV, fig. 2.)

Utilization.—The chief crops grown on this type are milo maize, kafir, sorghum, broom corn, and melons. Wheat is grown to a limited extent, though with little success. The first three crops named appear to be well adapted to the type. On account of the heavy subsoil found generally throughout the type the soil holds moisture well, and therefore in ordinary years these crops equal or surpass those on the heavier soils. The type seems to be particularly well adapted to watermelons and cantaloupes.

No estimate of the yields of the seed of maize, kafir, or sorghum was obtainable, as the entire crop is usually consumed as rough feed. In southeastern Morton and southwestern Stevens, as well as some other parts of Stevens, watermelons are grown to a considerable extent, chiefly for seed, of which the yield averages about 200 pounds per acre. The product is generally contracted for by seed houses of eastern cities for 12 cents a pound, making the income from an acre, therefore, about $24. Some cantaloupe seed is produced for the same purpose. The yield of cantaloupes is not quite so great as of watermelons, but the seed brings a higher price and the income is about the same. Broom corn is grown to a considerable extent in Stevens County and less widely in some others. It is grown chiefly for the brush and produced this year about 1 ton to every 5 acres, which is considered an average yield. For brush of good quality the price ranges from $75 to $175 a ton. The great difficulty in growing broom corn on the plains is that it is sometimes so brittle as to be almost worthless.

Not more than 10 per cent of this type is farmed at the present time. On account of the action of the high winds great care must be used in its cultivation. The loose soil is easily blown about after the native vegetation is removed, and it very frequently happens that winter wheat is blown out during the high winds of the spring

months. The practice of listing in the spring is one that has been found to be advantageous. This gives an uneven surface and thus affords more protection from the winds. Deep plowing is not as essential at the present time as upon the heavier types of the area, as the soil is loose and most of the rainfall soaks into the ground easily.

The adaptation of this soil to the cultivated crops, such as maize, broom corn, kafir, and melons, is generally recognized. Thorough cultivation is quite as necessary on this type as others for the double purpose of retaining moisture and keeping down weeds.

The present price of the land is determined more by its location with respect to railroad facilities than by the inherent value of the soil itself. Quarter sections in the vicinity of a railroad sell for $1,800 to $2,000, while those 30 or 40 miles from a railroad sell for from $800 to $1,200.

RICHFIELD LOAM.

Description.—The Richfield loam represents rather a condition than a soil type. It consists of an irregular mixture of sandy material with the heavier soils of the area. Frequently a few acres will consist of a heavy loam to silt loam of a dark-brown color having a depth of 12 to 14 inches, below which is a heavier stratum to 20 or 30 inches where the lighter colored silty material appears, while bordering this area will be found ridges of sandy loam or even loamy sand, less than a quarter of a mile in width. Occasionally considerable areas are found which are quite uniform in texture and structure; in such cases the surface loam, while quite tenacious, contains a considerable amount of fine sandy material. Again, the material may consist of silty sandy material, such areas generally being near the dividing line between the Richfield silt loam and the more sandy types. The type occupies considerable areas along the breaks or bluffs of streams.

Location.—The Richfield loam occurs in a number of areas in the counties of Hamilton, Stanton, Morton, Stevens, and Grant, and covers a total of 360 square miles. The areas of the type are irregular in shape, and, though some of them follow streams, they are not confined to any condition of topography or regional drainage. The largest development of this material is found along the North Fork of the Cimarron and its tributaries in northern Morton County. This consists of the Plains Marls somewhat mixed with sandy material, the latter being derived from sandstone farther west and from calcareous sandstone outcropping along these streams. The area in northern Morton is continuous with an area in northwestern Morton, where the loam contains considerable coarse sand. Soft calcareous rock is encountered in the shoulders of the ridges within 3 feet of the surface,

and much fragmentary calcareous rock is seen on the surface. Along the North Fork of the Cimarron was observed some soft sandstone outcroppings containing in spots apparently calcareous concretions. The small areas about 4 miles northwest of Richfield, Morton County, are somewhat rolling, with heavy areas intervening between the more sandy ridges. These heavy areas are frequently silty, with a heavier dark subsoil.

As found in northeastern Morton and southeastern Stanton the soil is a reddish-brown silty loam, containing fine sand to a depth of about 12 inches, where it becomes somewhat more loamy, containing coarse sandy material. The subsoil is a reddish-brown silty loam, mottled with white spots of calcareous material and containing very considerable amounts of coarse sand. This area is somewhat rolling. The small area about 4 miles east of Johnson, Stanton County, is of much the same character.

In northwestern Stanton is an area of somewhat roughly rolling land, due to the cutting of tributaries of Bear Creek. This consists of alternating ridges of light material and depressions of heavier material. Loam and sandy loam alternate, sometimes in large enough bodies to be separated. That portion mapped as loam here consists of alternating heavy sandy ridges and heavy loam depressions. In local spots in this vicinity is found a layer of somewhat adobe nature from 6 to 12 inches below the surface. This, however, was not found to be extensive. Other small areas of this type closely related to the sandy loam are found in western Stanton.

Irregular areas of considerable extent are found in Stevens County. The largest area, in the vicinity of Hugoton, consists of alternating sandy ridges and heavy depressions in such irregularity and so small that they could not be separated. A small part of the type about 3 miles south of Hugoton consists of heavy material from which the sand has been almost entirely removed by wind action. This body of 200 or 300 acres is entirely barren of vegetation, showing that the sand has been entirely removed. This illustrates how sand has been removed from other heavy areas which have since been covered with native vegetation.

Most of the other areas in Stevens County are similar to the large area in the central portion, except the more extensive area in the west side of the county. The soil here consists of about 6 inches of a dark-colored very fine sandy loam, with some silt. Below this is a crumbly heavy loam of a brown color to about 18 inches. From 18 to 36 inches appears a fine, loose, yellowish-brown, silty calcareous material. The fine sandy material has evidently been blown to its present position from the sandy area to the north.

Almost the entire area mapped as Richfield loam contains the loose calcareous, silty material within 3 feet of the surface.

Two small areas in northwestern Gray consist of a mixture of sandy loam, silt loam, and loam in such small and irregular areas that it was impossible to make any separation.

The type as found along the branches of Crooked Creek consists of weathered plains soil mixed to a considerable extent with sandy material. In this locality there are spots of light sandy loam also, but these were too slight in extent to be recognized on the map.

Topography.—The topography of the type is generally rolling. There is scarcely any drainage in areas on the plains, except from the ridges to the depressions. Where it occurs along the streams, as the Cimarron River and its tributaries and Crooked Creek, the surface drainage is directly into these streams. There is some drainage also from this type in Stanton County into the tributaries of Bear Creek.

Origin.—The greater proportion of this type was originally Plains Marl. It has been blown about to some extent by the winds, and sandy material from near localities has been mixed with it. As it occurs along the streams it is the product of weathering, erosion, and the addition of sand by the wind, the sand being here blown from the bottom of the streams or from sandy strata exposed on the slopes.

Native vegetation.—The native vegetation consists chiefly of buffalo and grama grasses, with some sand-grass. Scattering soapweed (yucca) is found generally over the sandier areas.

The crops of this type are similar to those of the sandier areas of the Richfield sands and sandy loams. Wheat also is grown to a slight extent, with some success on the heavier parts of the type.

Utilization.—Great care must be used in the cultivation of the sandier parts of this type on account of drifting. The heavier phase should be cultivated in much the same manner as the Richfield silt loam, being plowed deeply to enable absorption of rainfall and cultivated thoroughly for the purpose of retaining moisture. This heavy material should prove very good agricultural land, both on account of its texture and because the surface water from the higher ridges finds its way to this land, thus affording more moisture than the more level prairie receives. The heavy soil is practically impervious to water.

The heavier areas of the type are considered a little more valuable than the lighter areas, although the value is generally determined mainly by proximity to a railroad point.

RICHFIELD SILT LOAM.

Description.—The Richfield silt loam is one of the most extensive and important soil types of the southwestern part of the State. In general it is quite uniform, the slight local variations in color and texture occurring near the boundaries of the type. The soil is usually

a grayish-brown or brown silt loam, containing a considerable percentage of very fine sand. On account of the fineness of the sand the smooth feel characteristic of the soils derived from the silty deposits is retained. The depth of the top soil ranges in different parts of the area from 8 to 18 inches, but the usual depth is about 12 inches, which is near the average for the type. The subsoil is divided into two sections, the upper, a brown to dark-brown silty clay loam, with an average thickness of about 14 inches, which includes the lower limit of the zone of weathering; the lower, a calcareous, mealy silt loam or silt of a grayish-yellow color. This layer extends to a depth of 3 feet or more and represents more nearly the original material from which this type was derived. The upper zone of the subsoil varies according to the amount of weathering that has taken place and depends to a large extent upon topography. On level areas this portion of the subsoil is deeper, heavier in texture, and darker in color. During the greater part of the year this soil is easy of cultivation, but it becomes dry and compact in the late summer months, especially in the unbroken prairies, and there assumes a somewhat granular structure, which increases with depth throughout the darker material, and is more marked on the level than on the rolling portions of the type. On the more rolling land the soil is thinner and has a higher sand content, owing to the removal of some of the finer material by erosion. It is also lighter in color, on account of the smaller amount of organic matter in the soil. The heavy layer is also frequently absent, as the rapid run-off prevents the water soaking into the soil and weathering the underlying material. This soil gradually changes from west to east, becoming darker in color and more deeply weathered in proportion to the increase in rainfall.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Richfield silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
25357	Soil	0.0	0.4	0.3	2.8	15.7	69.9	11.1
25358	Subsoil	.0	.3	.2	4 2	25.5	55.4	14.2

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 25358, 7.75 per cent.

Location.—The Richfield silt loam occupies a large acreage in the southwestern part of Kansas. It is not so uniform and continuous over large areas as the Colby silt loam, as the erosion in the valleys and the outcrop or overdrift of sandy materials has produced other soil types, leaving this type in more irregular tracts. The counties

and parts of counties in which it occurs in the largest proportions are as follows: Northern Clark, southeastern Hodgeman, eastern Ford, southern Gray, Haskell, western Grant, Stanton, southern Hamilton, and northern Morton, with isolated patches in Rush, Ness, Pawnee, and other counties south of the Arkansas. It covers the great divide between the Arkansas and the Cimarron, where the original plateau is but little eroded, and its boundaries terminate where the streams have cut down into the sandy strata of the Tertiary or where it has been covered by the loose sandy materials transported by wind or water.

North of the Arkansas River the principal area of the type extends from Kearny County eastward past the town of Ford and westward in very irregular areas in some places to a distance of 20 miles. There are also several irregular areas lying between Pawnee River and Walnut Creek. This soil merges so gradually into the other silt types, the Colby silt loam and the Greensburg silt loam and silty clay loam, that the boundaries indicated on the map must be regarded as approximate and in many places arbitrary, as the character of the materials is so similar that it would require much time to make an accurate separation.

Topography.—The topography of the Richfield silt loam is that of a broad, sloping plain broken by the valleys of numerous drainage channels. These water courses have cut down till they now occupy channels 60 to 70 feet below the general level of this type. Numerous short draws with steep banks are tributary to the streams and in many sections have produced a sharply rolling topography. The prairie breaks away sharply toward the south along the valley of the Cimarron. Here a number of deep drains have cut away the original surface, leaving long, narrow divides upon which there is good farming land of the Richfield silt loam.

The greater part of the type has sufficient relief to insure good drainage. After a heavy rain water stands for a time on the level areas, but on the more broken portions near the streams and draws the drainage is excessive.

Erosion, though steadily going on, is not so rapid as on the silt soils of the east and we find none of the badly dissected areas of the Bad Land type of erosion.

Origin.—The Richfield silt loam is the weathered product of the Plains Marl, modified by the addition of a small amount of fine sand through wind action.

Vegetation.—The native vegetation of this type is that common to the heavier soils of the High Plains and consists of buffalo and grama grasses, with a few scattered patches of bunch grass and Spanish dagger (yucca) near the sandy areas.

Utilization.—The Richfield silt loam is well adapted to the growing of wheat. The relative percentage of the area devoted to wheat gradually increases as we go from west to east across the area of this type. The Turkey Red and Kharkof are the varieties most grown in this part of the State and these give good yields in seasons when other varieties fail to make a profitable crop. The average yield of wheat when calculated for a series of years is somewhat low, probably not exceeding 10 bushels, and for the average farmer this is barely within the limit of profitable production. Exceptional yields in very favorable years have run as high as 30 bushels an acre, but usually 18 to 20 bushels in such years is good for the average farmer. Some corn is grown, especially in the eastern portion of this type south of the Arkansas River, but yields are rather uncertain under present methods. In favorable seasons this crop will probably yield an average of 25 bushels per acre, but if a series of years over the whole area is taken into account the average would be much below this figure. Kafir, sorghum, and milo maize are grown to a limited extent as forage crops.

Occasional total failures of all small grains and more rarely of the sorghums greatly reduce the average for all the crops grown. Toward the western limits of this type the average crop is so small that farming has always been precarious and the greatest care is necessary in the preparation of the land, particularly on the heavier portions of the type.

RICHFIELD SILTY CLAY LOAM.

Description.—The soil of the Richfield silty clay loam consists of 4 inches of dark-brown or chocolate-brown loam or silty loam. This is usually underlain by a layer of heavier material, consisting of a silty clay loam of adobelike structure, which extends to a depth of 18 to 24 inches. This in turn is underlain by a lighter colored compact silty loam containing some calcareous material. The surface material contains a considerable quantity of very fine sand and occasionally the surface layer is nearly a fine sandy loam in texture.

The type is somewhat variable in structure and texture. Occasionally as in the vicinity of Roanoke, in the southern part of Stevens County and over a considerable area northeast of Richfield, Morton County, the surface silty material is scarcely more than 2 inches in depth, the heavy loam or clay loam appearing near the surface. A considerable proportion of the type between the forks of the Cimarron River consists of a lighter colored surface soil. In parts of northern Morton and southern Stanton Counties the soil consists of about 8 inches of chocolate-brown silt loam, with occasional areas where the surface is a heavy loam. Over a considerable area northwest of Richfield the yellowish silty material does not

appear in the subsoil, the heavy loam or clay loam extending to a depth of more than 3 feet. Where the silty material appears in the subsoil there is apparently present a considerable content of calcareous material. The type in southern Morton along the Oklahoma line contains a larger amount of sandy material in the surface than the typical soil. Irregular ridges of sandy loam extend toward the south into the Richfield loam in this vicinity, some of which are large enough to be separated while others are so small and irregular that separation on a map of this scale is impracticable.

The boundary line between this soil and the Richfield silt loam is somewhat arbitrary, owing to the fact that there is a gradation from one to the other so gradual that a definite boundary can not be located. A considerable area in the northeastern part of Morton County resembles one soil as much as the other. Here the surface material may be closely related to the silt loam and the subsoil may resemble the heavier silty clay loam; on the other hand the surface may be dark and the subsoil consist of grayish, powdery, silty loam.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Richfield silty clay loam:

Mechanical analyses of Richfield silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
25374	Soil	0.0	0.2	0.4	2.8	5.8	81.9	8.7
25375	Subsoil	.1	.4	.3	1.2	3.7	78.6	15.7

The following sample contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 25375, 2.45 per cent.

Location.—The extensive development of the type is found in Morton County, between the forks of the Cimarron River and extending northward into Stanton County. The type appears again along the Kansas-Oklahoma line in southern Morton County.

Topography.—The type is undulating to slightly rolling over most of its extent. However, in southern Morton County the type is more rolling, having numerous ridges of lighter material extending through it. Several slight draws, between the forks of the Cimarron, give some relief to the otherwise nearly level surface.

There is scarcely any drainage of the Richfield silty clay loam in northern Morton and southern Stanton Counties. The North Fork of the Cimarron and its larger tributary drain only a short distance from the immediate channels. The rain water runs from the slight elevations to the lower areas, where it sinks into the ground or is removed by evaporation. Between the forks of the Cimarron, however, there are slight draws of considerable length which drain a portion of the type in this region.

Origin.—The Richfield silty clay loam is the product of the weathering of materials of the Tertiary age.

Utilization.—Very little of this type is under cultivation at the present time. Where sown, however, wheat has done well when there was sufficient rainfall. A few very good fields of milo maize were observed. Some attempt has been made in a few localities to grow alfalfa on this type, but with slight success, on account of the lack of moisture and poor cultivation. Two or three good fields of corn were observed. A few miles west of Richfield there is an orchard of peach and apple trees. Here the soil was kept constantly under cultivation, an endeavor being made to conserve moisture, and the results were striking. There had been very little loss of trees on account of the lack of moisture, and good results were being obtained.

The older settlers of this vicinity have found that the best methods of agriculture consist in deep plowing and thorough cultivation. Many of the newer settlers have not sufficient horsepower for deep cultivation, and the difference in results is easily seen. On account of the heavy, impervious character of the soil and subsoil it is essential that as deep a moisture bed be prepared as possible. After that it is best to cultivate often, both to conserve moisture and to remove weeds. Cultivation should take place after each shower immediately the soil becomes dry, keeping a mulch on the surface so that evaporation may not take place. Deep cultivation after the ground is well plowed is not necessary.

Quarter sections of land in the vicinity of Richfield are held at about $1,500, while those 5 miles or more away are held at from $1,000 to $1,200. On account of the heavy character of the soil and its moisture-retaining powers this type is perhaps somewhat more valuable than other types of the area. There is less danger of blowing of the surface soil on this type than on others. However, on account of its heavier character it is more difficult to cultivate, particularly in the first breaking, than are the other types.

MISCELLANEOUS.

HAMILTON SOILS.

Along the northern slope of the Arkansas Valley, particularly in Hamilton County, the Tertiary deposits have been very largely removed by erosion, exposing the underlying calcareous Cretaceous shales. In some places Tertiary remnants several feet in thickness remain, while in others the shales or their weathered products constitute the surface material. In small areas beds of gravel are found. The variation in the character of the material gives rise to differences in the soils, but it was not practicable to show the types

separately on the map and they have accordingly been grouped as the Hamilton soils.

The largest area of these soils occurs in Hamilton County, and here they have common characteristics. The usual surface soil, to a depth of 8 to 12 inches, is a heavy silty loam or silty clay loam, brown in color, possessing a characteristic adobe structure, which causes it when drying to break up into small cubes. The subsoil to a depth of 36 inches is a yellowish-gray silt loam, very loose and incoherent, with mottlings of white calcareous material. In some places the accumulation of lime is in such abundance as to make the subsoil almost white at 36 inches. The soil is difficult to work when either too wet or too dry, but breaks up fairly well if plowed when it has the right amount of moisture.

In other places the surface soil contains a noticeable amount of sand and fine gravel, probably released by the disintegration of the sandy Tertiary strata and shifted by wind and water to its present position. A characteristic feature of all the soils in this section is the presence of waterworn gravel in greater or less abundance. It is usually scattered over the surface, but in some places there are gravel beds several feet in thickness and 25 feet or more in width.

The main body of this type lies principally in Hamilton County north of the Arkansas River, but extends a few miles over into Kearny County. There is also a small detached area east of Garden City.

The characteristic native vegetation is a small reddish sedgegrass. It is tough and is not as palatable to cattle as the buffalo and grama grasses. On the less rolling areas the latter grasses are in sufficient abundance to furnish good pasturage.

Very little of this type is cultivated, but where crops are grown they are, in order of importance, wheat, maize, broom corn, and kafir.

Another area of this group of soils occupies a narrow strip north of the Arkansas River almost continuously from a few miles east of Garden City eastward to the central part of Ford County. Like the area already described, the soil has no uniformity of texture, but may be regarded as a mass of sand, gravel, and pebbles mingled with and often cemented by calcareous material. Below the zone of weathering, usually at 2 to 3 feet, there is encountered the compact calcareous mass of the formations known as the Mortar Beds.

In the small uniform areas of tillable land the soil is a brown heavy silt loam, having a depth of 8 to 12 inches. It sometimes has an adobe structure and breaks up into cubical clods upon drying. The subsoil is a yellowish-gray silty loam mottled with white calcareous matter, which increases at lower depths. This phase occupies a line of bluffs north of the Arkansas River, where incoming streams

have eroded the slopes and carved ravines and sharply rolling hills. The surface is rough and not suited for agriculture.

RUSSELL SANDY LOAM.

Description.—The texture and surface features of the Russell sandy loam varies in its detached, widely separated areas. In the northern part of the State this type is usually a light-gray to brown very sandy loam, with a depth of 6 to 15 inches, underlain by a subsoil of heavier texture than ranges from a heavy sandy loam to a fine sandy clay loam.

In the detailed survey of the Russell area several bodies of this type were found.[1] The following description was given of the soil as it occurred in that section of the State:

Among the upland types the Russell sandy loam ranks in agricultural value between the Sedgwick clay loam[2] and the Benton loam.[3] In parts of the area it suffers the same topographical disadvantage as does the Benton loam, but where it occupies more level areas it is successfully cultivated to a greater diversity of crops than either of the other upland soils. The depth of the soil varies from about 10 to 15 inches, and is a light-gray to grayish-brown sandy loam, the sand content of which ranges from a medium to fine grade. Occasionally on rounded knobs and small ridges there is a large proportion of waterworn pebbles scattered on the surface and mixed with the finer sand. These pebbles range in size from coarse particles to fragments an inch or more in diameter. These areas, however, are of infrequent occurrence and of small extent.

From 10 to 36 inches the subsoil differs little from the soil, except that the sand content increases and the color becomes lighter with depth. Rounded quartz pebbles are also frequently encountered in the subsoil.

Location.—The location of this soil is usually in the vicinity of the rivers, and rarely extends more than a few miles north or south from these streams. The largest unbroken area is situated north of the Smoky Hill River, south of Bunkerhill, and covers about 5 square miles.

The surface of the sandy loam areas, especially along the Saline River, is very rough. Occupying, as this type does, the lower slopes of the hills and the rounded knobs between them and the bottom lands, it is intersected by the many arroyos or draws that extend to the rivers. The areas along the Smoky Hill River are generally of a more rolling nature, the draws are shallower and less numerous, and the country gradually becomes more level to the eastward, especially on the north side of the river.

A great part of this soil originates directly from the Dakota sandstone, which outcrops along the lower slopes of the hillsides and caps the summits of the low ridges and knolls, but in many instances it is found at such an elevation above the sandstone that it can not be influenced by this formation. These areas are supposed by geologists to have been deposited by early floods which brought down large amounts of material from the western mountains. The abundance of waterworn pebbles which are often found on the ridges indicates that at least in part, this soil was deposited by water at an early date, before the rivers had cut down their channels to their present level.

[1] In the Russell area, Kansas, this soil was mapped as the Sedgwick sandy loam.
[2] Summit silt loam and silty clay loam of the present survey.
[3] Benton stony loam of the present survey.

Where the surface is level or gently rolling, fair yields are obtained of every crop adapted to the climatic conditions of the area. It is always more productive in a wet season, since it does not seem to withstand the effects of drought as well as the heavier soils. In seasons of much rainfall it often produces a wheat crop equal to that of the Sedgwick clay loam. On the level areas wheat yields range from 10 to 15 bushels per acre and corn produces about 15 bushels. Oats, kafir corn, and sorghum are also cultivated with much success. The rougher and more hilly sections are mainly used for pasture and for the production of such forage crops as kafir corn and sorghum. The cultivation of melons and potatoes has been attempted on this soil with good results.

The Russell sandy loam warms up earlier in the spring and can be plowed sooner after rains than the other upland soils. The sand content also prevents it from baking into hard clods. It is therefore well adapted to crops requiring intertillage.

ASHLAND SILT LOAM.

Description.—The soil of the Ashland silt loam is a light-brown to dark-brown silt loam, with an average depth of 12 inches. The subsoil is a yellowish-brown to dark-brown compact silty clay loam, which becomes more compact with increase of depth. Occasional streaks of calcareous material are found below 2 feet, and boring and cuts over the terraces on which the type occurs reveal the presence of beds of sand and gravel below 10 feet. The terrace materials in some places have been found to extend to a depth of 40 feet. Near the outer borders of the valley, the material crops out and the Red Beds formation is exposed. There are also knolls of the Red Beds material projecting above the general level at intervals throughout the valley.

The soil of the Ashland silt loam is friable and easily tilled. The drainage is good, as its elevation above the stream and the sandy and gravelly nature of the subsoil are both favorable.

The following table gives the average results of mechanical analyses of samples of the soil and subsoil of this type:

Location and topography.—The type is found in only one area. It occupies a terrace in a valley of Bear Creek, which broadens out near the town of Ashland. The unusual widening of this valley in excess of the needs of the creek suggest that it had its origin in some other process than the usual channel cutting. From a careful study of the surrounding topography and the other valleys of similar occurrence in the State, geologists have concluded that this is a valley of subsidence, due to the removal of salt and gypsum beds in the Permian below and the subsidence of the overlying Tertiary strata. The area is continuous extending from several miles below Ashland to several above, spreading out in a fan-shaped area above the town. The greatest width from east to west is about 4½ miles and from north to south 8½ miles.

Origin.—This type has a mixed origin. The portion of the silt covered plains that subsided has undergone more rapid weathering than the upland soils and there has been added to the soils so formed, in various places, considerable quantities of colluvial wash and thin terrace deposits. It is probable that the silt mantle has been worn thin in places and that the deep beds of sand and gravel may belong to the original Lower Tertiary strata and not to the terrace deposits.

Utilization.—Nearly the whole of the type is under cultivation and constitutes one of the best farming soils of the area. With proper management it is a good wheat soil. In good years high yields are obtained, 33 bushels having been reported. In ordinary years the yield is somewhat above the average for the region, which is not far from 12 bushels. Kafir and Indian corn are grown to some extent, but the profits derived from wheat growing have discouraged any extensive diversification of crops.

FOWLER SILTY CLAY LOAM.

Description.—The soil of the Fowler silty clay loam consists of a dark-brown to black heavy silt loam, with a depth of 12 to 16 inches. It grades into a light-brown to brown silty clay loam, which continues to a depth of more than 3 feet. The last 4 or 5 inches is mottled with a white calcareous mealy material.

In the northern part of the area mapped as Fowler silty clay loam, the soil has been modified by sediments brought down by Crooked Creek and other smaller streams. This phase consists of 8 to 12 inches of a fine loam, underlain by a brown silty clay loam, which usually becomes lighter in texture and contains more white mottlings at between 30 and 36 inches.

In the northern part of the area covered by this type, some fine sand has been deposited over the surface by the streams, which drain the higher lying Richfield silt loam. On the eastern side of the area the surface has some sand, which has been blown from the body of Pratt sandy loam, lying immediately to the east.

A small depression or lake bottom occurs in the central part of the type. Here the soil is a dark-brown to black clay loam and the subsoil a brown clay loam mottled with white. This soil cracks and checks badly when dry. Two miles west of Fowler there is a knob of grayish-white mealy silt loam, covering an area of about 1 square mile.

Topography.—This type occupies a wide area in the valley of Crooked Creek, which is locally known as Artesian Valley, in the northeastern part of Meade County and the southern part of Ford County. The surface is nearly level, sloping gently toward Crooked Creek. On account of the flatness of the surface and the imperviousness of the subsoil, the drainage is somewhat sluggish, but not so much so as to injure crops.

As the valley of Crooked Creek, both above and below the Artesian Valley, is narrow and has steep slopes, this wide portion would seem to be due to some other cause than the normal channel cutting by Crooked Creek. It undoubtedly owes its origin to subsidence due to the removal of salt and gypsum in the Permian Red Beds formation, which underlies the area. This subsidence is still going on, as is shown by recent cracks and sinks.

Utilization.—Nearly the whole of the type is under cultivation. Alfalfa is the principal crop, covering 11,000 acres in the valley. Four or five cuttings are made and the average yield is nearly a ton to the cutting. The soil is well adapted to the other crops of the region and small grains and corn are grown to some extent. It is considered one of the most valuable soils in this entire section. Its position in the valley and the presence of artesian water give favorable moisture conditions and increase its value for agriculture.

PROTECTION LOAM.

In the valley near Protection occurs a body of soils differing somewhat from any found elsewhere in the area. The texture varies considerably, but is most often a loam, and the soil has been classed as the Protection loam.

In the section south of Protection the soil is a grayish-brown loam to silty loam carrying a rather high percentage of very fine sand, underlain by a light brownish yellow or pale-yellow friable loam subsoil. Both soil and subsoil are calcareous, white spots of lime being frequently found. Mounds and ridges of fine sandy loam are scattered through the level areas of loam.

East or northeast of Protection the soil is darker and heavier, although the sand present is much coarser, owing to the association of this area with the Pratt coarse sandy loam, an accumulation of organic matter resulting from the low position and comparatively poor drainage. The surface is level to gently undulating, with occasional low ridges.

The development of the Protection loam is too limited to be of very much agricultural importance in the area as a whole. The type is, however, a good soil, well adapted to wheat, corn, and alfalfa.

LACUSTRINE SOILS.

SCOTT SERIES.

The Scott Series includes soils of lacustrine origin which represent reworked material from the areas of loess soils. The two types mapped in this survey as silt loam and as silty clay loam differ in the amount of clay present. The silt loam occurs on the edge of a

depression in Scott County and is but slightly heavier than the silt loam of the uplands. The silty clay loam occurring in the center of this basin and in several other areas was deposited from still water and has the heavier texture.

SCOTT SILT LOAM.

Description.—The surface soil of the Scott silt loam consists of a dark-brown to drab-brown heavy silt loam, with a depth of 12 inches. Between 6 and 12 inches the color grades to a lighter shade, while the texture passes to that of a silt loam not quite as heavy as the first 6 inches. The surface is friable and easy to cultivate at the optimum moisture content, but when wet it is more difficult and clods when plowed, though the clods are reduced without much difficulty. The subsoil from 12 to 24 inches consists of a light-drab smooth and slightly cohering silt loam, while from 24 to 36 inches the material grades into a light-gray silt loam very incoherent when dry. The subsoil upon exposure bleaches to a whitish color.

Location and topography.—This type occupies the gentle slopes lying between the areas of the Scott silty clay loam of the lower lands and the loess soils of the higher plains. It occurs in one small area, containing a few square miles, south of Scott, where it surrounds the area of Scott silty clay loam of the lake bottom.

Origin.—The drainage waters flowing over these slopes to the basin below weather the surface soil and deposit more or less material derived from the soils above this level, increasing the silt and clay content and the amount of organic matter in the top soil of the lower lands. The difference between this soil and the high plains soils may be very slight or quite pronounced, depending on the amount of weathering and deposition that has taken place in any particular locality. This type is never covered by standing water, as is the case of the lower-lying lands, its slope and elevation giving it good drainage. The type as a whole is more alkaline than the upland soils, but there are only a few spots where salts have accumulated in harmful quantities.

Utilization.—The characteristic native vegetation of the type consists of buffalo and grama grasses. Salt grass is found in small depressions within the type and along the lower part of its area where it joins the Scott silty clay loam. The cultivated portion of the type is farmed to wheat and other general farm crops. Wheat yields from nothing to 25 bushels, depending on the season, but the average is about 12 bushels. Corn yields from 10 to 25 bushels; kafir, 1 to 3 tons of rough feed per acre. Very little alfalfa is grown on account of the depth to water and the unweathered condition of the subsoil. The type lies in an excellent topographic position for irri-

gation, but very little irrigation is practiced at the present time because of the lack of water in sufficient quantities, but if the deep-well district is extended, irrigation will become general on the type.

SCOTT SILTY CLAY LOAM.

Description.—The surface soil of the Scott silty clay loam consists of a dark-brown to drab-brown heavy silt loam to a silty clay loam, varying in depth from 12 to 16 inches. Where the land has been cultivated for some time the surface soil is loose and friable from the incorporation of organic matter, while on uncultivated areas the soil is more compact and consequently hard when dry and stiff and sticky when moistened.

The subsoil consists of a silty clay loam gradually becoming heavier as the depth increases until 30 to 32 inches is reached, where it changes to a silty clay. To a depth of 20 inches the color is a medium brown, becoming lighter with increasing depth. Small particles of calcareous material are found at 24 inches and the proportion of such material increases to a depth of 36 inches. In structure the subsoil is hard and brittle when the moisture content is low, but becomes slightly plastic and tough upon moistening.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Scott silty clay loam.

Number.	Description	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
25376.....	Soil.....	0.0	0.6	0.6	3.6	14.8	59.7	20.4
25377.....	Subsoil.....	.0	.2	.4	1.8	16.8	59.7	20.7

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 25376, 3.25 per cent; No. 25377, 8.68 per cent.

Location.—The type is found in depressions which form basin areas and is derived from the deeper weathering of the loess and Plains Marl and from the wash from higher lands. Lying as it does in a lower position than the surrounding plains, the surface water of the higher land drains upon it, and in slowly sinking through the soil to the underground stream channels both the surface and subsoil are weathered to a greater degree. The drainage water also carries with it a certain amount of the loess of the higher land and deposits it upon the surface. Thin sheets of these sediments are noticeable, especially after heavy rains.

Numerous small areas of the type too small to map occupy the "buffalo wallows" or small circular depressions thickly scattered over a large area in the western part of Kansas. Here the type is a

dark, tenacious clay 2 to 6 feet deep, underlain by a heavy silt loam. Large cracks form in the soil as it dries. The type is difficult to till and has little agricultural value.

Drainage.—By reason of its topographic position, this type of soil is poorly drained. There are no streams and water either sinks through the soil to an outlet or collects in small depressions and evaporates. This evaporation causes the accumulation of small quantities of alkali salts in the depressed areas of the type. Only after heavy spring rains is the land partially covered with water. Under ordinary conditions the water draining into this soil does no more than sufficiently wet the soil for successful plant growth.

Native vegetation.—Salt grass mixed with grama grass makes up the greater part of the native vegetation, while bluestem occurs in small patches and buffalo grass is found on the higher portions of the type in which the content of alkali salts is less.

Utilization.—Alfalfa is grown over the greater part of the type, as the soil is well adapted to this plant on account of its alkaline nature and the close proximity of the water table, which here varies from 15 to 30 feet in depth. Alfalfa yields from 3 to 5 tons of hay per acre. Kafir, milo maize, and corn are also grown to a limited extent for feed on the individual farms located on the type. The money crop is alfalfa. This soil is recognized as most productive, and the greater part is farmed. Land values range from $40 to $60 an acre.

HOISINGTON SERIES.

HOISINGTON SILTY CLAY LOAM AND CLAY.

Description.—The Cheyenne Basin, in the central part of Barton County, consists of a series of lacustrine soils ranging in texture from heavy silt loams to clays. The most extensive soil is a dark-brown or drab silty clay loam 10 inches deep, underlain by a dark-drab heavy clay. The soil is not easily worked unless it has just the right content of moisture. It clods when plowed, and in some places it is difficult to reduce to good condition for planting. In most localities, where the heaviest type is found, however, the large percentage of organic matter causes it to break up more readily.

On the lower-lying areas on which water stands in some seasons of the year and evaporates from the surface, there has been some accumulation of soluble salts, principally sodium chloride, but on the more elevated areas that may be cultivated alkali does no injury to crops.

The lighter textured soils occur on the borders, where silty material has been washed in from the surrounding country or along the stream channels that wind through the basin. On the western

edge the Hoisington silty clay loam gradually merges into the alluvial soils of Blood Creek.

Location and topography.—The Hoisington silty clay loam and clay are confined to one compact area, almost oval in shape, which extends in a southeastern direction from the town of Hoisington. The basin has a diameter from north to south of about 7 miles and from east to west of about 11 miles.

The surface of the basin is almost level, and as drainage has been but poorly established, a large part of it is covered with standing water during rainy seasons. Some portions are scarcely ever dry, but toward the western side there are fields that may be cultivated without much danger.

Origin.—The type is purely lacustrine in origin. The basin itself is one of the most interesting subjects from a geological standpoint in this part of the State. It has without question been formed by the subsidence of land which originally stood at a level with the surrounding country. The most plausible theory for the sinking of this region is that the underlying Permian formation, composed largely of silt and gypsum beds, was removed in solution by subterranean waters and the overlying Cretaceous strata subsided into the cavity thus formed. Since this depression, streams draining the surrounding country have dumped their deposits into this basin of restricted drainage. The depression has now filled, until drainage has been reestablished in an imperfect way with the Arkansas, but so slowly do the waters move across the old lake bed that the finer materials have been deposited to form the silty clay soils.

Utilization.—The greater part of the type has no economic use except for grazing. The coarse water grasses, though not of the best feeding value, are abundant and furnish subsistence to a large number of cattle.

In the western edge of the area and in the vicinity of Hoisington there are several farms in the basin. Some are comparatively free from overflow, but on others the crops are injured at times by high water. The soil itself is of high productiveness and good crops are secured from the higher areas. Corn and kafir are the principal crops.

SOILS FROM WIND-LAID DEPOSITS.

COLBY SERIES.

The Colby series includes the weathered products of the extensive loess deposit that covers the northwestern corner of the State. One type has been established, the Colby silt loam, which consists entirely of the more or less weathered loess.

COLBY SILT LOAM.

Description.—The Colby silt loam, stretching as it does entirely across the area from east to west, and subject, therefore, to weathering under different conditions of rainfall, necessarily presents various phases of texture, color, and topography, but the soil has everywhere certain common characteristics, and taken as a whole is remarkably uniform for so extensive a type.

The usual texture of the surface soil is a silt loam, with a small proportion of very fine sand and sufficient clay to give the soil a slightly compact structure. The color is variable, depending upon the advancement of weathering and the quantity of organic matter present. In the northwestern part of the State it is an ashy gray, while in other sections a yellowish or brownish gray predominates. The depth of the surface soil varies with the state of weathering and the amount of erosion from 6 to 24 inches, but the usual depth is 12 to 18 inches.

There are usually two distinct zones of the subsoil, the upper consisting of heavy weathered material and the lower of loose, mealy, unaltered loess. The heavy stratum beneath the silty top soil is a silty clay loam or heavy silty loam, having a brown color and a compact structure. It varies in thickness from 2 to 8 inches in different parts of the area. It is better developed in the more southern counties covered by the type, and in Greeley County it is very heavy and has a slightly reddish color. Where the clay zone is very hard and compact it is called "hardpan" by the farmers, but it rarely gives trouble in the field.

Below this zone to a depth of more than 36 inches is the less weathered loess. It is a light-yellow to yellowish-brown silty loam, closely approaching a pure silt. It has the loose, smooth, mealy feel characteristic of the unweathered loess in the Mississippi Valley.

The Colby silt loam is easy to cultivate when once broken, but the virgin sod is hard and compact and the first breaking is difficult. With the proper moisture content the soil breaks into a mellow seed bed; when dry it is hard to plow and cloddy and difficult to handle subsequently.

When conditions are favorable for a thorough preparation of the land it retains moisture fairly well. While not so efficient in this respect as the more sandy land, the surface soil is not so easily drifted, as it can be broken into small clods, which, while small enough to form a fairly good mulch, are too heavy to be moved by winds of average velocity.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Colby silt loam:

Mechanical analyses of Colby silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
25355	Soil	0.0	0.2	0.2	0.6	21.3	66.1	11.6
25356	Subsoil	.0	.1	.1	.3	9.4	78.2	11.8

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 25356, 4.56 per cent.

Location.—The Colby silt loam is the most uniform and extensive soil type in the survey, covering a vast area in the northwestern part of the State. It lies entirely north of the Arkansas River and is the prevailing type over more than two-thirds of this region. Its area extends south almost to the Arkansas River and across the northern part of the area and passes out in the northwestern corner through Smith County as a strip 15 to 20 miles wide. The main body of the type is broken only by stream valleys and their attendant strips of rough land.

Topography.—The type has a topography ranging from sharply rolling to almost level, depending upon the progress made by erosion in cutting back into the original loess covered plateau. In the eastern part of the area where the streams are larger and the rainfall heavier, sculpturing has gone on to such an extent that almost the entire surface has been given a rolling topography. Where the valleys are wholly within the loess mantle, the soils have been included within the Colby silt loam type, but where the lower shales and limestones have been exposed and their weathered products have influenced the character of the soil such areas have been included in other types. Toward the west fewer streams are found and the divides are broader and more level. The largest level area is found in Greeley, Wichita, and Hamilton Counties, where the flatness of the surface is so pronounced that few drainage channels are established and there is practically no run-off of the rainfall.

Origin.—The Colby silt loam is derived through weathering from the loess. A sheet of this material mantles the entire northwestern part of Kansas and its extent is closely indicated by the limits of this soil type. It covers the northern part of the State to a great depth, only the deeper stream valleys cutting into the underlying material, and it gradually thins out toward the edges of the Colby silt loam, where it thinly covers the Plains Marl to the south and the limestone rocks to the east. As before stated, the material has weathered in some places more than in others, but everywhere the surface has been influenced to some extent by weathering, giving rise to differences in texture and structure mentioned above. Naturally, where

erosion has been less active and on level areas where the surface has been more subject to standing water weathering has gone on more rapidly and we find darker and heavier soils. This is also noticeable as we pass from west to east, where the increase in rainfall has hastened the rate of weathering.

Native vegetation.—In its original state this type of soil was covered by a thick growth of buffalo, grama, and other native grasses. Practically no trees grow on the High Plains, but it is possible with care to grow trees of useful species on nearly any part of this soil.

Utilization.—Since the Colby silt loam lies for the most part in the region of deficient rainfall, the problem of utilization involved in the settlement of the plains is pressing here. The texture of the soil is favorable to the retention of moisture if it can be prepared in time to receive the rainfall of the summer and autumn months. The crops grown on this type vary according to locality. In the northern part of the area wheat is by far the most important crop, with barley probably second, and Indian corn, milo maize, and kafir grown to some extent. Toward the south and east the production of wheat decreases, and tilled crops, such as corn, sorghums, and kafir, are more extensively grown. Within the last two years broom corn has been given much attention, but owing to its fluctuating price and uncertain demand it is not yet certain whether it will become a staple crop of the area.

The yield of wheat varies in different years from almost total failure to 25 to 35 bushels per acre. The average varies from 10 bushels in the extreme west to 13 bushels in the eastern part of the area.

The average for corn varies in different years, but the general average is probably about 15 bushels. Milo maize and kafir are the surest crops and rarely fail to make a profitable yield.

MISCELLANEOUS.

CANYON LOAM.

Description.—The Canyon loam occupies a topographic position between the Colby silt loam and the sandy soils of the Tertiary, and it resembles all these soils in some respects. The usual surface soil is an ashy-brown loam with a noticeable proportion of fine sand, giving it in the roads the appearance of a sandy loam. The subsoil to a depth of more than 36 inches is a yellowish-gray silt loam containing some sand. Fragments of the Mortar Beds formation, which is composed largely of sand and gravel cemented by carbonate of lime into a conglomerate, are present in the soil and scattered over the surface. The greater part of the soil material, however, is derived from the loess.

Location.—The type is found in very irregular areas along nearly every creek in the northwestern part of the State. The largest areas occur along the tributaries of Republican River and Beaver Creek, in Cheyenne and Rawlins Counties. There are also extensive areas on the tributaries of Smoky Hill River. As the loess thins out toward the east the areas of the soil become smaller, for here the streams within short distances cut into the shales of the older formations.

Topography.—As the type occurs along the stream slopes on the descent from the High Plains to the lower valleys the topography is usually hilly and there are no considerable areas of level or undulating land, though much of the hilly portion is not so rough as to prevent cultivation. On account of the rapid run-off from the sloping land, erosion is rapid and the calcareous rocks are frequently exposed or broken up and scattered over the surface.

Origin.—As already stated, this soil has been formed by erosion and weathering of the loess and the lower-lying calcareous Tertiary material. More or less of the loess has been washed down and distributed over all parts of the type where the Mortar Beds are exposed, and the resultant soil is a mixture of the two in varying proportions. It differs from the Benton stony loam in that the shales of the Benton and Niobrara formations have not been exposed and their weathered products do not enter into it.

Native vegetation.—The original vegetation on this soil was a growth of the coarser grasses, consisting principally of sedge, bluestem, and bunch-grass, with small proportions of buffalo and grama grasses.

Crops.—Very little of this soil is cultivated, on account of its very hilly character, although in those places where the surface soil is mainly loess it is farmed successfully and yields as well as the Colby silt loam, and in sheltered places, where protection from hot winds is had, even better. However, the greater part of the type is better suited to ranching and is mainly used for that purpose. Wheat is not extensively grown, as machinery can not be used to advantage on land of this character of surface. Corn, milo maize, and kafir are the principal crops. Their average yields are about the same as on the Colby silt loam.

AMARILLO SANDS.

The soil of the Amarillo sands to an average depth of 16 inches is a brown slightly loamy sand, carrying a small percentage of silt. The sand is a mixture of all grades, differing in this respect from most dune sands. There is also usually a small amount of gravel distributed through the soil. The subsoil to a depth of 30 to 36 inches is a sand of similar texture, having a slightly reddish color,

Below this depth a mass of limestone fragments or white calcareous material is usually found, the quantity being sufficient to make boring with the ordinary auger used in this survey very difficult.

The surface of the sand is loose and incoherent, and while it is not moved by the wind at present, difficulty would be experienced from drifting if the land were plowed or the vegetation removed.

Location and topography.—The Amarillo sands occur on a range of hills with dunelike outlines and the type is distinguished from the Dunesand by the character and size of the grains and by the calcareous nature of the subsoil. These hills are on the south side of the Cimarron River, in the southern part of Clark County and the southwestern part of Comanche, and in both counties they extend to the Kansas-Oklahoma line. The topography in Comanche is not so hilly as in Clark County, and the soil is slightly heavier in texture.

Origin.—The origin of this soil is not clear. The topography would indicate wind action, but the partly weathered limestone near the surface gives evidence of weathering in place. It is probable that both agencies have contributed to its formation and its deposition in its present position. A sandy calcareous rock has weathered and partly contributed to the soil and this product has been covered and modified by wind-carried drifting sand from the river. It is certain that there has been much moving of the sandy surface to and fro by the wind.

Utilization.—The native vegetation is that characteristic of very sandy areas in this latitude. Sagebrush, coarse weeds and grasses, and yucca, with occasional patches of buffalo grass and bunch grass, make up the vegetation. There is sufficient native vegetation to hold the soil against the action of the wind.

Nearly all of this land is devoted to grazing. No farm entirely of this type of soil was seen. Some farms within the area mapped as Amarillo sands usually utilized for the production of crops narrow stream valleys or depressions, which had a heavier or better watered soil than the average of the type upon the hills. Drainage over the type is usually excessive, and the soil is leachy and does not retain water. Some portions of the type will probably be farmed, as it is not without agricultural possibilities, though it is a great risk to depend on this type alone. Wheat, corn, and kafir may be grown in the more favorable localities, but low average yields must be expected, especially in the case of wheat.

DUNESAND.

Description.—Wind-formed sand hills are a feature of the topography over a large part of southwestern Kansas. The material of which they are composed varies slightly in different parts of the area,

but in general it is a loose sand with more or less fine soil. Differences in the texture of this material are determined by the sources from which it is derived and the extent of the weathering to which it has been subjected. Sand may be supplied either by the deposits of streams or by out-cropping sandy strata of the Tertiary and Cretaceous or, as is the case over a large part of the dune area, from both of these sources. The Dunesand which is blown from the river beds is a fine to medium grayish-yellow sand to a depth of 3 feet or more, while that formed from local weathering of the older rocks is a fine to medium reddish-yellow sand of a somewhat loamy texture to an average depth of 18 inches, underlain by a slightly sticky reddish-yellow sand to a depth of 3 feet or more. Where the two are mixed there is every gradation of texture between the two.

The Dunesand of this area is never clean, as is the case with many wind transported sands, for not only is there always a small quantity of fine material present in sands that have been blown only a short distance but weathering takes place rapidly in the feldspathic materials. Thus on all the dunes except the most recent and migratory some weathering has taken place, and the finer products of this decay have given a surface covering of more loamy sand. Large areas of ancient dunes that have long been stationary have now so weathered that they have been classed in this report with the sandy loams and loamy sands of the Pratt series, and the term Dunesand has been restricted to those sands that are still in a measure loose and incoherent and liable to be shifted by the wind if the vegetation, which acts as a bond, is removed.

Location.—The most extensive area of Dunesand in the area follows the Arkansas River in its course through the State. It enters the State as a narrow strip but widens as it approaches Garden City and attains a width of about 20 miles south of that place. It gradually narrows toward Dodge City and continues as a narrow strip a few miles wide. Opposite Dodge City there is a break for several miles where it is absent. It again reappears and runs in an almost continuous strip to the eastern part of the area. South of Ellinwood, in the eastern edge of the area and bordering the salty marshes, there is an area of many square miles covered by sand dunes. Along the Cimarron River, in the southwestern corner of the State, there are considerable stretches of Dunesand flanking the stream. It is more broken than that along the Arkansas, but occurs at intervals in small and narrow areas until south of Ashland, in Clark County, where it widens out and covers a large area which extends over into Comanche County. In addition to the principal areas of the type bordering the large streams there are many small detached areas in Seward County and at intervals throughout all the country covered by the Pratt and Richfield series, where for lack of vegeta-

tion or for some other reason the movement of the sand has not been checked long enough to allow it to be weathered into the more loamy types. There are also small areas, as the one in Barton County east of Cheyenne Basin, which are due perhaps to accumulation of sand from the exposed Dakota sandstone.

Topography.—The topography of the Dunesand is that typical of wind-formed hills, consisting of sharply rolling knolls or irregular ridges. In only a few places are the hills now in motion, as vegetation soon takes root and binds the sand and protects it from the action of the wind. There are valleys between the hills and ridges. These are usually quite small. Occasionally they widen out and are of importance in the agriculture of the region, as the soil is of a more loamy nature than that higher on the hills. As a rule these productive valleys are too small to be mapped.

Origin.—From the position of the large areas of dunes that follow along the southern side of the streams, it would seem that they were formed from the sandy deposits of the river bed and this is partly true, but in many places it is probable that the streams have cut into the sandy strata and their weathering has released sand that has contributed to the accumulation by the wind. It is naturally difficult to determine, as these sands are similar in appearance, what proportion is derived from each source. The isolated areas at some distance from the streams in most cases have derived their material by the disintegration of some local outcropping of sandy shale or sandstone. The sand in the bed of the Arkansas, from which the sandhills are constantly recruited, was originally a part of the granitic rocks of the Rocky Mountain region, and the sand of the Tertiary strata, which makes up the other portions of the type, no doubt had originally the same source, having been brought down by the streams in former geologic ages.

Native vegetation.—The native vegetation, which has played so important a part in holding the sand hills and thereby become a most important agent in the soil formation of the region, consists chiefly of sagebrush, Spanish dagger (yucca), and bunch, bluestem, grama, and buffalo grasses. The latter grasses are not so abundant as on the more loamy soils, occurring only in patches. In many places, as on exposed hillsides where the soil is very loose, it is unwise to remove the native vegetation, as the sand may begin to drift and get beyond control.

Utilization.—The greater part of the Dunesand is used for pasture to good advantage, on account of the variety of the grasses and the watering places found at frequent intervals. Farming is confined to localities protected from the winds or to valleys where the soils are loamier than the average. Great care must be exercised in the cultivation of this type to prevent drifting, as entire farms in these

hills have been blown away when a very small area was loosened by the plow. Corn and kafir have proved to be the most profitable crops.

The greater part of the Dunesand has passed into private ownership, being usually held by small cattlemen, who run cattle on the neighboring public land and are not dependent on the homesteaded quarter section for a living. There are still scattered quarter sections that have not been taken up and are still open to homesteaders. In addition to public land, the Government holds a large tract west of Garden City as a forest reserve. This land is leased to the cattlemen for grazing under proper supervision. Extensive experiments are being made in this region to determine the possibility of foresting these sand hills.

On account of the scanty rainfall and the leachy nature of the soil there are few varieties of trees likely to succeed. The cedar and certain species of pine give the most promise of success.

ALLUVIAL SOILS.

Laurel Series (Types Undifferentiated).

Description.—The Laurel soils form the surface covering of the immediate valley of the Arkansas River from the point where it crosses the Colorado-Kansas line eastward to a point a few miles east of the town of Ford, in the great bend of the river. Besides their position these soils have certain characteristics in common, as regards their agricultural possibilities. They range in color from a gray to brown, the prevailing color being dark gray. The various grades of material composing these soils are much interbedded and stratified. A usual feature and one that particularly distinguishes these soils from those of the smaller streams is the presence of a bed of gravel at a depth of 3 to 10 feet below the surface, through which passes the subterranean flow of the Arkansas, furnishing subirrigation in many places and greatly enhancing the agricultural value of the land.

In common with types of the Laurel series found in other States there is present in the soil a large percentage of soluble salts. On account of the open nature of the subsoil, which allows good drainage, there is little danger of an excessive accumulation of alkali over any large area, though with a less favorable subsoil condition this might easily take place.

The lowest member of the alluvial deposits is the bed of sand and gravel over and through which the Arkansas River flows. It varies in width from 180 yards to a quarter of a mile and is continuous along the length of the river in its course through the State. Coarse sands and gravel make up the greater part of this deposit, but lenticular beds of silt and clay occur at intervals. The whole mass is

porous and the greater part of the flow of the stream finds its way for a long distance beneath the surface. In extreme droughts the entire flow of the stream is absorbed, leaving the bed in the western part of the State completely dry. This belt becomes more silty toward the outer edge and might be farmed in places if it were not so subject to overflow. As its low position will not permit cultivation it has no value except that the grasses and shrubs furnish a little pasturage.

The entire bottom of the Arkansas is in most places so narrow and so many types of soil occur in narrow bands and small patches that a separation of all the existing types on a map of small scale was impossible. In the detailed survey of the Garden City area these types were separated, mapped, and described, and reference will be made in this report to the information collected at that time.

The coarsest member of this series was called the Laurel sandy loam in the report on the Garden City Area, and described as follows:

This type of soil is composed of various grades of sand and gravel mixed with a variable percentage of silt and clay. In some places the percentage of fine material is great enough to give the soil the characteristics of heavy sandy loam; then again this fine earth may be present in quantities so small as to give the soil approximately the texture of a gravelly sand. The different grades of material are so intermingled as to render impracticable any attempt to differentiate them into separate types of soil. The depth of the soil varies greatly, but it is nearly always underlain by a bed of sand and gravel at from 18 to 36 inches.

There are two phases of the Laurel sandy loam in this area, occupying the first and second bottoms, respectively. The second-bottom phase lies north of the river and is usually found about midway between the river and the bluff line, but in the eastern part of the survey it is found skirting the bluff line. Much of it occurs west of range 32 W., around and west of Garden City. The surface is usually gently rolling, with an occasional abrupt depression caused by the filling in of some former river channel, and in some places shall arroyos finger out from the higher grounds adjoining.

The first-bottom phase lies parallel to and on both sides of the river and adjacent to it, except at a few points where either the Laurel loam or the Colorado sand supersedes it. It includes also the larger islands of the river. Sand ridges, covered with vegetation, frequently appear lying parallel to the course of the stream. Between the narrow ridges, strips of clay and silt are found. In fact this phase of the type grades quickly from a clay in some places to almost pure sand in another, and, from the various textural materials composing it and thrown together by the shifting currents of the river, it closely resembles meadow.

With the exception of that portion of the type lying immediately under the bluff, the Laurel sandy loam is wholly of fluvial origin representing a surface that has at different times been occupied by the river bed. The fact is emphasized by the presence of a bed of coarse sand and gravel at varying depths underlying all of the type found in the river bottom. The underlying sand and gravel is practically the same in appearance as that found in the present river channel. Much of the material in the first bottom has evidently been deposited by comparatively recent fluvial action, having been transported along distances from the west by the river during flood seasons. As the floods sub-

sided the coarser particles were first deposited, while the fine material, such as silt and clay, remained in suspension in the water left in the sloughs and pools, and were laid down on the coarser material beneath. The river occasionally overflows at various points and adds considerable silt and clay to the soil, the result being that the texture is gradually becoming finer and the soil stratum deeper. That portion of the type found along the bluff line has doubtless been formed from the weathering of the Tertiary grit or Mortar Beds found just above it. This weathered material has been carried by the sudden and heavy rains down into the lowlands and spread out in a sinuous line, reaching from near the White Woman Valley to the east boundary of the survey.

The Laurel sandy loam is practically free from harmful amounts of alkali, and only a few points are found where indications of alkali were pronounced, yet if irrigation should be practiced the heavier phases of the type might give some trouble. * * * Judging from the sand and gravel contained in this soil, the principal minerals composing it are quartz and feldspar.

The second-bottom phase of this soil is generally so open that moisture either evaporates or passes readily down below the zone of root action before the plant can use it. The soil greatly needs more fine material, and this can be added by a free use of the sediment-laden flood waters. This phase of the type lies in a position quite favorable to irrigation, and the greater part of it lies under the ditch, but unfortunately many of the farmers do not take advantage of the opportunity afforded them for irrigation. Since it occupies such an important position in the agricultural development of the valley, the necessity for the use of the annual flood waters can not be too strongly urged. On the heavier phases fair crops of alfalfa, sorghum, sugar beets, kafir corn, and macaroni wheat are sometimes harvested. Under favorable conditions of cultivation and moisture, from 8 to 12 tons of beets, one-half to 1 ton of alfalfa hay, and 2 tons of sorghum or kafir corn per acre can be produced, but the average yields are far below these figures. Vegetables seem to do well when sufficient water is applied, and it is not improbable that such crops as potatoes and cantaloupes would pay handsomely even in the light sandy phases, if sufficient water can be obtained.

The first-bottom phase is at present used largely as range land and permanent meadow. It doubtless could be made to bring profitable returns if used for general agricultural purposes. The water table is too near the surface for the growth of alfalfa, but almost any shallow-rooted forage crop adapted to the climate would do well. With proper cultivation, there is little doubt that this soil would produce cantaloupes of excellent quality.

The loam is found in strips in all parts of the valley covered by the Laurel series, and the total acreage is greater than that of any other type. Where the valley is narrow it is usually the predominating type outside of the gravelly stream channel. In the Garden City area and in other wider parts of the valley it occurs as irregular strips winding around among the sandy loams and clay loams. The following description of the type as it occurs near Garden City is taken from the report of the survey of that area.

This type of soil as found in the Garden City area, presents features varying somewhat according to its location. It is the best soil in the Arkansas Valley and is especially well developed in that part of the valley lying immediately east and west of Garden City.

As a second-bottom type it is not found on elevations of more than 10 or 15 feet above the present river bed; hence the water table can always be reached by deep-rooted crops, such as alfalfa and clover. The surface is generally level, with just sufficient relief to give good drainage. The soil is a rather heavy dark-brown loam, becoming lighter in color with depth. It varies considerably both in texture and depth of soil and subsoil. In some places the percentage of sand is rather large, but these areas are not of sufficient extent to have any marked effect on the agricultural value of the type. These variations are due largely to the mode of deposition. The subsoil is much more sandy and gravelly than the soil. Sometimes almost pure sand is found at from 30 to 36 inches, and the type is nearly always underlain by a bed of gravel at from 3 to 6 feet. As it appears in the valley the soil seems to have a twofold origin. The lower portions show the former presence of the river channel, where the coarse sand and gravel are not unlike that found in the river bed of to-day. The upper portion has been formed by the occasional inundations of the river when it began to abandon its old channel and swing southward and by the washing of the silt and clay from the adjoining uplands.

Another phase of the Laurel loam occupies a portion of the first bottom on both sides of the river, usually occurring in long, narrow strips parallel with the course of the stream. The largest body is found on the north side of the river, extending a few miles east and west of Garden City. The soil varies from a dark-gray heavy sandy loam to a heavy silt loam, with only a small percentage of sand. The average depth of the soil is about 12 inches, but its depth varies in places, owing to its irregular deposition by fluvial action and the occasional floodings to which it is subjected. It is underlain by an interstratified fine sand and silt of mottled reddish and gray color. As a result of deposition by the shifting currents of the river the depth of both soil and subsoil varies considerably, but it is always underlain at from 26 to 36 inches by a bed of water-worn gravel. As the subsoil is very porous, the soil is easily and quickly saturated and is easily dried out when the flood season is over. In places, however, the subsoil has sufficiently fine texture to lift the capillary water up from the water table, which is only from 4 to 6 feet below the surface during the dry season. Weathering and decaying plant remains have had a marked influence on the texture of the soil, and its composition is such as to render it an excellent soil for the growth of grasses and various other forage crops, except alfalfa, for which the water table is thought to be too near the surface. When the soil is as much as 12 inches deep, good crops of beets, sorghum, and cantaloupes no doubt could be produced, although it is used at present especially as pasture and permanent meadow.

As before stated, the type as a whole is the best soil in the Arkansas Valley, the areas occupying the second bottom being the more valuable for agricultural purposes. Without irrigation alfalfa yields from one-half to 1½ tons per acre. By the aid of irrigation, using windmills, as much as 23 tons of sugar beets has been obtained from this soil. While the second bottom phase is especially adapted to the growth of alfalfa and sugar beets, all other crops grown in the area, such as macaroni wheat, oats, spelt, rye, barley, millet, potatoes, etc., would doubtless give large yields on this soil. The texture is excellent, the moisture-holding capacity is ample, the subsoil is quite favorable to root growth, and the soil is well supplied with humus.

The silty clay loam is the heaviest soil of the Laurel series in the Arkansas Valley. The surface covering is a heavy silt loam or silty clay loam to a depth of 10 to 14 inches. There is usually a small percentage of sand of various grades and sometimes fine gravel, but

not in sufficient quantities to change the heavy texture. The color ranges from a chocolate brown to dark brown, and in some places it is almost a drab. The land clods when plowed too wet, but it is not difficult on the higher land to reduce it to good condition. On some of the lower flats, where the soil has the nature of the adobe, it is difficult to work, except under the most favorable conditions as regards moisture. The subsoil is heavier than the soil and consists of a heavy silty clay loam to a depth of 24 inches. Below this it is a silty clay, very tough and tenacious.

This soil is found in the second bottom of the Arkansas Valley, both on the north and the south side of the river. The following facts regarding the soil are taken from the report on the survey of the Garden City area, in which it was described under the name of Colorado adobe:

The first 3 to 5 inches of the soil of the Colorado adobe is a heavy medium to fine sandy loam of a dark or chocolate-brown color. There is also a small percentage of coarse sand and gravel, the latter having been brought up from the underlying gravel beds by prairie dogs, while the finer grades of sand have been deposited by the wind. In the section from 5 to 18 inches less sand and more silt and clay is present, giving a texture heavier and more nearly a clay loam. This layer has a very pronounced adobe structure, is very hard, and when crushed breaks into cubes. It is rather impervious to water. When heavy rains occur the water stands until evaporated in the "buffalo wallows" that dot the surface. The adobe stratum is in turn underlain by a rather heavy fine sandy loam of a lighter color, which becomes generally lighter in texture with depth until a bed of old river sand and gravel is reached at from 4 to 8 feet below the surface.

The surface of this soil is only slightly rolling, and is nearly level in most cases. The greater portion of it lies 8 or 15 feet above the water table. This and the additional fact that its surface is slightly rolling, that its subsoil becomes lighter in texture with depth, and that it is underlain at about 50 inches by a bed of sand and gravel tends to furnish this type with excellent drainage features.

The Colorado abode owes its origin in great measure to river action, but has since been materially modified by weathering and by the wash of clayey material from the hillsides. There is some wind-blown sand on the surface, sufficient in amount to make a sandy loam that may be from 2 to 3 inches deep in some places. The material for the first 12 or 18 inches has undergone considerable weathering, and there is incorporated with it considerable quantity of organic matter.

This type contains a small percentage of alkali. No serious trouble has as yet been experienced with it, but its presence indicates that the condition might become troublesome should irrigation be practiced.

This "gumbo soil" will produce good crops of sorghum, wheat, and even alfalfa, if only enough water can be obtained. It needs deep plowing, proper tilth, an occasional saturation—say, two or three times a year—followed always by a good 3-inch mulch of loose dry soil, which must continually be maintained. With these conditions fulfilled there is no doubt that excellent crops can be obtained each year, whereas at present only moderate yields are secured in favorable seasons.

At present some sorghum, alfalfa, and kafir corn are produced on this type, and a yield of from one-half to 1½ tons to the acre is secured, but when properly handled the Colorado abode will produce excellent alfalfa, beets, sorghum, and other crops that may be grown at this elevation.

Arkansas Series.

From near Ford to the eastern part of the area the lower alluvial soils above the overflow line have been classed with the Arkansas series. Only one type has been mapped—the Arkansas fine sandy loam—but it has a range of texture from a very sandy loam to a silt loam, and in a more detailed survey several types might have been established. These soils are somewhat darker in color than the soils toward the west, and the percentage of soluble salts is less. They are underlain by sand and gravel beds at various depths.

Arkansas fine sandy loam.

Description.—The term Arkansas fine sandy loam has been applied to the soil lying along the Arkansas River next above the strip of river-wash material. It includes soils of all gradations of texture between very sandy loam and silt loam. The sand in all phases is of the finer grades. A large proportion of silt is characteristic of the type. The most common soil is a grayish-brown fine sandy loam, with a depth of 14 to 18 inches. It overlies a yellow silt loam, or silty sandy loam, which has a depth of 3 feet or more. Scattered gravel occurs on the surface and in the lower portions of the subsoil, and the amount increases downward until at a depth of a few feet a bed of gravel is struck. This gravel represents deposits made when the river bed was at this level, while the silty surface soils are more recent deposits derived from comparatively still water in times of overflow.

There is considerable variation in texture over this type at different points along its course. Near its western edge it carries a large quantity of sand, giving it the nature of a very sandy loam. In the narrow bands of the type, where there is a rapid change from sandy to heavy silty loam in a short distance from the river, the texture is more variable, with silts and very fine sands predominating over most of the areas.

In the body of the type south of the Arkansas River the texture of the soil has been modified to some extent by sand blown in from the adjacent sand dunes to the south.

Location.—These soils occur as a continuous body on the northern side of the Arkansas River from a point about 5 miles east of Ford to near the town of Great Bend. From this point it continues eastward to the edge of the area in a narrow but continuous belt. Another area begins just south of Great Bend, on the opposite side of the river, and extends to the eastern edge of the area.

Topography.—The type covers a succession of level or very slightly rolling flats. There are usually two well-marked terraces, known as first and second bottoms, covered by this soil, and the line of demarcation between them is in most places an abrupt drop, which presents the greatest inequality of the surface. Occasional low, sandy ridges or mounds owe their origin to wind action. At the present time only a small percentage of the type is subject to overflow. The soil is loose and well drained, except in a few low-lying areas, where the soil is darker in color, heavier in texture, and somewhat impregnated with alkali.

Utilization.—The type is nearly all cultivated, and on account of the subirrigation it is regarded as one of the best soils of the valley. Wheat is one of the principal crops, with a yield of about 15 bushels per acre. Corn yields from 10 to 35 bushels to the acre, depending upon the season. Though crops are more certain on this soil than on the upland in very dry years, there may be a failure, particularly on the higher land. Alfalfa is grown to a small extent, but the acreage will probably be increased. Many shade and timber trees are grown, of which the catalpa and cottonwood are most common. A few apple orchards in Barton County are on this type of soil, but the more sandy sections are not to be recommended for this fruit.

Lincoln Series (Types Undifferentiated).

Along the streams that drain the vast extent of the silty soils of the plateau there are strips of alluvial land so varied in texture that it has not seemed advisable to separate them into types. Although the total area of these valley soils is small and comparatively unimportant, in some sections of the State they are of great interest from an economic standpoint, since their higher average productiveness gives stability to the agriculture of the region. This classification of the undifferentiated alluvial soils of the Lincoln series has been made to include the soils of all the recently formed river flood plains in Western Kansas that have been built up wholly or in part by sediments brought down from the silty soil areas. A common characteristic of these soils, aside from their silt content, is their dark color. This distinguishes them from the red soils of the Miller series, while the absence of the substratum of sand and gravel differentiates them from the Arkansas series. The soils along streams in different parts of the area have their peculiarities and hence will be described in some detail.

Along the creeks in the northern part of the State, the bottoms have a wide range in texture. On some streams there are alternate or successive bands of material, each with its prevailing texture, which may range from sand to clay. In other sections along one bend of the

stream there may be a body of heavy soil, while bordering the next a light-textured soil may be found depending upon the assorting power of the current at each place. Usually, however, some one grade of material predominates along each stream.

The silt loams and silty clay loams are more continuous along the streams in the northern part of the State, including the Republican, the Solomon, and the Saline Rivers and their tributaries. As a rule the headwaters of the streams, where they break upon the upland, have a silty alluvium, composed simply of transported loess, but lower down a certain amount of assorting takes place and we find bodies of either coarser or finer soils, though much silt is still present. The soils of the northern stream valleys may be described as silty loams, or more rarely silty clay loams, with a depth of 18 inches. They are dark gray to dark brown in color. It is seldom that they present any difficulties in tillage, as they are friable and readily broken up by the plow. The subsoil is a grayish-yellow silt loam, usually friable, though occasionally the amount of clay is sufficient to give an adobe structure.

Some of the streams toward the eastern edge of the area have made extensive erosions in the sandy shales and through additions of the débris from these rocks the sand content of the valley soils has been increased. This is particularly true of the Smoky Hill River, which has much sandy land in its lower valleys, though its headwaters and small tributaries bring down silty sediments.

A phase deserving special mention is found in the soils of heavy texture which occupy high river terraces. The lower bottoms along Pawnee River and Walnut Creek and the outer terraces of the Arkansas are covered by soil of this phase. The soil is a light to dark brown heavy silt loam, with a depth of 14 to 18 inches, underlain by a dark-brown silty clay loam. The subsoil becomes lighter and more friable at a depth of about 36 inches. In Ash Valley in the northern part of Pawnee County, the soil is a dark-brown silt loam, 14 inches deep, underlain by a dark-brown silty clay loam to more than 36 inches. On the outer edge of the Arkansas bottoms the top soil may vary from a silt loam to a silty clay loam, with the usual zone of heavier subsoil, which in turn gives way to a more friable material below 36 inches. The heavier areas of the phase are found where the incoming streams, such as Walnut and Blood Creeks, have spread their deposits for some distance over the valley.

This heavier phase, as a rule, occupies a second or higher terrace, which represents an alluvial deposit when the stream had a higher level than at present. While the soil occurs on terraces of various heights, the topography of each is fairly level, being broken only by a few valleys of the tributary streams. These second bottoms are usually 30 to 40 feet above the streams and are safe from overflow.

The alluvial flood plains of the streams that drain the Tertiary in the southern part of the area vary more widely in texture than those farther north, and the soil areas are neither so uniform nor so extensive. Sands and sandy loams are the principal types here, though a large percentage of silt is always present and the amount increases toward the headwaters that drain the silty upland. Over most of these valleys the subsoils are lighter in texture than the soils and more loose in structure. The principal bottoms in which these conditions prevail are along Bluff, Crooked, Mulberry, and Maple Creeks, parts of the Medicine Lodge and Cimarron Rivers, and several other small creeks.

Most of these are composed of reworked Tertiary material. Usually the silty loam washed from the upland has mingled with sands and gravels of the coarser Tertiary strata.

The Alluvial land along the Cimarron River is not extensive in area and the texture is exceedingly variable. Probably the greater proportion of the bottoms consists of fine sandy loam, but this material is so mixed with heavier soils that a separation seems impracticable. The sandy loam is usually of a grayish or grayish-brown color to 3 feet. Frequently small quantities of fine gravel are found. The heavier areas of loam and clay are usually darker in color and are underlain by sandy and gravelly material.

Along the North Fork of the Cimarron in southern Grant County, about 7 miles southeast of New Ulysses, is an area of 2 or 3 square miles in extent which occupies the position of a second terrace. The soil consists of loam to sandy loam of a brownish color, underlain by sandy and gravelly material. Most of this area is under cultivation and fair crops are being produced.

The bottom land occurs along the Cimarron River practically across the area, though in southern Grant County the area is so narrow that it is not separated on the map. Very little of the bottom along the North Fork of the Cimarron was shown on the map.

The topography is generally level. The drainage is good, the surface water running directly into the river. On account of the sandy nature of the material much of the water seeps out through the soil. Some of the heavier areas are slightly lower than the immediate banks of the streams and water stands on them for some time. There are occasionally spots of quicksand in the bottoms, but they are usually of small size.

The soil type occupying the bottoms along the lower course of Bear Creek consists of a gray or grayish-brown silt loam, containing very little fine sand. Below 12 inches, however, the subsoil becomes more sandy, and a high percentage of very fine sand is found from 2 to 3 feet below the surface. The color remains the same down to 3 feet or more.

Bear Creek has its source in Colorado, flowing generally eastward in Kansas through Stanton and Grant Counties. In northeastern Stanton and northwestern Grant and southern Kearny Counties the creek spreads out over a considerable flat, which is about 15 miles long and from 1 to 3 miles wide. At the western end of this flat, in the vicinity of the loamy fine sand on the uplands, the soil of the bottom is somewhat more sandy than the greater proportion of the material. This area of 2 or 3 square miles consists of a very fine sandy loam containing much silt and of a grayish-brown color to a depth of 8 or 10 inches. The subsoil is somewhat more sandy and coarser in texture than the surface soil. The deeper subsoil, below 2 or 3 feet, consists of a very fine sand and silt of gray color.

The topography is level to gently undulating. The channel or bed of Bear Creek, which here becomes very small, crosses the axial portion of the type to disappear almost entirely at its northeastern extension. Practically the only avenues of escape for water from this flat are by evaporation and seepage. However, in time of very high water the creek overflows the higher land to the east and finally finds its way into Lakin Draw. This area has probably been influenced to some extent by the sandy material blown from the extensive sandy areas to the north. The soil has a high lime content, but no evidences of alkali were observed.

Utilization.—Where the alluvial soils are not too light in texture or too rough to be tilled, they are in cultivation. They constitute the most valuable lands of their sections, and since crops are more certain than on the upland types, farming is on a surer basis. Very little land is irrigated in the smaller valleys, but subirrigation at a greater or less depth greatly increases the possibilities of successful agriculture. The crop which greatly enhances the value of the land is alfalfa. It not only provides a valuable product for sale, but it supplements the pasture in any system of stock raising and gives increased stability to this business. Alfalfa may be cut three or sometimes four times in a season. The yield decreases toward the western part of the State, where the subirrigation is not so well supplemented by the rainfall. The average annual yield in the eastern tier of the counties is about 4 tons, while in the west it is about 2 tons. In either locality it is one of the most profitable crops that can be grown. All other crops suited to this section are grown on the bottom lands. In the eastern counties small grains and corn are extensively grown and in some places apple orchards do well. Toward the western part of the State the sorghums are commonly grown. All crops yield better than on the uplands, as they get some benefit of subirrigation and are protected to some degree from the hot winds, but the short-rooted crops can not make use of the subsoil water as well as the deep-rooted alfalfa.

FIG. 1.—SORGHUM ON THE RICHFIELD SILT LOAM, NORTHEAST OF SANTA FE, KANS.

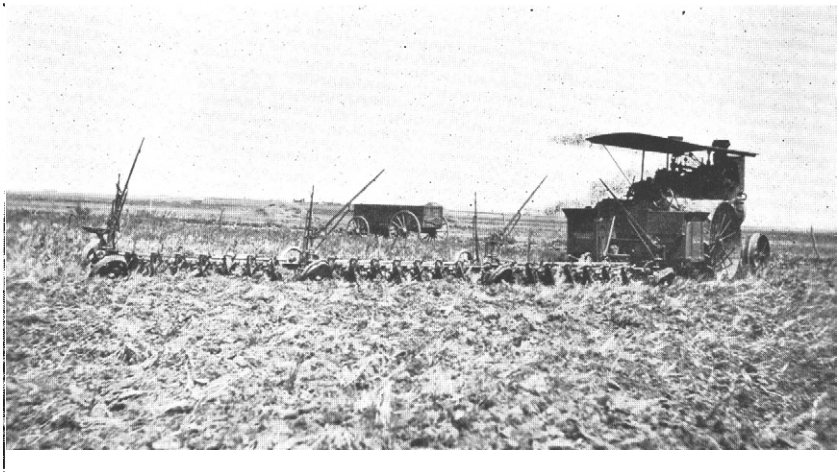

FIG. 2.—STEAM PLOW.

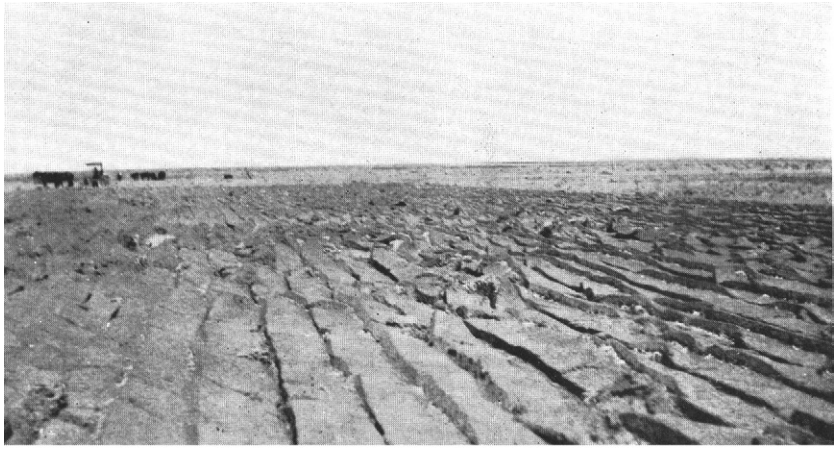

FIG. 1.—FIRST PLOWING OF THE RICHFIELD SILT LOAM, SHOWING LARGE FURROW SLICES OF PRAIRIE SOD.

FIG. 2.—FURROWS MADE BY LISTING.

MILLER SERIES.

The soils of the Miller series are distinguished from other alluvial soils of the area by their reddish color. They occur along the streams that flow through the Permian Red Beds and represent this material reworked by streams. Two types were established—a sand and a silt loam. The valleys are all narrow and the soils of various textures occur in bands too small to be separated; hence the entire bottom was mapped as being of the most extensive type.

MILLER SANDS.

Under this description are included the members of the Miller series coarser than the silt loam. The material is a recent alluvium covering the narrow flood plains of some of the streams that have cut down into the Red Beds of the Permian and have carried away and redeposited along their course the red sands of the Vernon series, together with a coarser material brought down from the areas of Pratt gravelly sandy loam. In places the sand has been blown from the stream channel by the wind and dropped on the adjoining flats in drifts and small dunes, giving the areas a choppy topography. In general this material is a mixture of loose reddish sand and fine sand without any marked change to a depth of 3 feet. It represents unassorted material thrown down by swiftly flowing streams, principally in time of flood. A small percentage of gravel through the deposits is common and in places there are layers of gravel interbedded with the finer materials.

These soils occur chiefly along the Salt Fork and its tributaries. An area too small to indicate on the map makes up a first bottom for some distance along the Medicine Lodge River.

Practically none of these soils are used for farming.

MILLER SILT LOAM.

Description.—The term Miller silt loam is applied to the red alluvial silt loam built up of sediments brought down by the streams from the Permian Red Beds. As it is deposited by waters which carry various grades of sediments no uniformity can be expected. Beds of silts, silty clays, and sandy loams may alternate or be intermixed, and often the valleys may be made up of alternate bands of soils of varying texture. The soil to a depth of 16 inches is usually a light reddish brown to chocolate-brown silt loam, containing noticeable amounts of fine sand. The subsoil is more variable, but in the larger areas it consists of a brownish-red to deep-red silt loam to a depth of more than 36 inches. It nearly everywhere carries a small percentage of sand, ranging in size from fine to medium.

The soil of the type along the Salt Fork River is a heavy reddish silt loam, underlain by a red silt loam. The soil is heavier than the subsoil and clods when worked too wet. White incrustations and salt grass indicate the presence of alkali.

On the flats of the Cimarron River south of Protection the soil is a brownish-red silt loam to a light clay loam. The subsoil from a depth of 18 inches varies from a reddish silt loam to a red clay loam. Areas of the type also have excessive alkali in spots.

Location.—As already noted, the Miller silt loam occurs along those streams which pass through the Permian Red Beds. It is confined to the southwestern part of the area, the largest body occurring along Medicine Lodge River in Barber County. In the bottoms of the Salt Fork the type occurs as small areas, only three of which were large enough to map.

Native vegetation.—The native vegetation of the alkali areas is chiefly salt-grass and a few alkali-resistant weeds. A sparse growth of trees fringes the streams along which the type occurs, but they are usually small. Cottonwoods and elms are the most common species.

Utilization.—The Miller silt loam seems to be very productive where it is cultivated in the Medicine Lodge Valley. The soil is easily tilled. Crops can be put out at an early date and the subirrigation makes the yields certain. Corn makes a good crop and yields in favorable seasons from 25 to 40 bushels an acre. Alfalfa is the most profitable crop, 4 or 5 cuttings being secured each year, with a yield of more than 4 tons to the acre on well-seeded fields. When a seed cutting is made, usually the third during the season, the yield is 4 to 9 bushels of a good grade of seed. The greatest difficulty in keeping this land in alfalfa is the tendency of weeds to crowd out the alfalfa after a few seasons. A partial remedy is to disk the field in early spring. In the vicinity of Lake City practically all of the alfalfa is hauled to the alfalfa-feed mill, where it is ground, sacked, and sold for feed. The usual price secured is $7 a ton.

This soil supports a growth of sagebrush, salt-grass, and cottonwoods, and in places grasses of higher value for grazing. It is a valuable part of the large pastures of this section, on account of the springs which occur in it and the trees that give shelter to the cattle in winter and shade in summer.

MISCELLANEOUS.

MEADOW.

Description.—Those soils, occupying the first bottom of the Arkansas and the Cimarron Rivers which are subject to overflow by every rise of the river have been classed as Meadow. They occupy the

same relative position as the first member of the Laurel series, and, like that phase, there is a wide variation in texture. The immediate river channel is a bed of sand and gravel, loose and porous, and saturated at a short distance below the surface by the subterranean flow of the Arkansas. On the outer edges of the first bottom the soil becomes more silty and there are strips of silty clay where conditions are favorable for a still-water deposit. The soil in such localities consists of 10 to 12 inches of a dark-gray or mottled yellow and drab silty clay, underlain in most places by a grayish-yellow clean sand, carrying a large amount of gravel, which increases at lower depths until the gravel of the river bed is reached.

On the south side of the river sand from the dunes has blown over the bottoms, greatly increasing the sand content of the surface soils, but usually the alternate strata of light and heavy material are found at a slight depth.

Location.—A continuous strip of this Meadow occurs along the Arkansas on both sides of the stream and extends from a point just east of Ford northeastward to where the river leaves the area. It rarely has a width of more than a mile, and gradually merges into the heavier soils on the north side and into the sand dunes on the south. The soils along the Cimarron, in Clark County, have also been included in this type. They consist principally of low-lying sandy and silty loams, with no uniform texture over any considerable area.

Topography.—While all parts of these soils are low and subject to frequent overflow, there are some inequalities of surface over the area. Old stream channels traverse the bottoms, and sand banks and gravel beds have been heaped up by the rushing waters. On the south side of the river and on the north, near the sandy river bed, there are small mounds of drifting sand.

Utilization.—The principal product of this land is the timber, which it furnishes for posts and other farm uses. The cottonwood and the elm are the most common trees. Some pasturage is afforded by bluestem, joint-grass, and other plants suited to the conditions of these soils.

SALTY MARSH.

Description.—The term Salty Marsh has been applied to the marshy alkali flats and stream valleys in the eastern part of the area. The feature that distinguishes the Salty Marsh from the other alluvial soils of the area is the accumulation in many places of alkali and the general presence of salt in the marsh waters. The salt of these areas is principally sodium chloride and is no doubt brought in solution from the salt deposits that underlie this region so extensively.

The soil is typically a mottled drab and yellow to dark drab silty clay, underlain by a mottled drab and yellow silty clay. Sand washed down by the creeks or blown in by the winds from the surrounding sandy types has modified the surface in many places, so that there are small spots of sand, sandy loam, and loam scattered throughout the areas of the type.

Location.—The Salty Marsh extends as a bottom along Rattlesnake Creek, having a width of from one-half mile to 2 miles, from a point in the southwestern part of Stafford County northeastward to near the edge of the area. It then widens out into an area covering several square miles.

Topography.—The portion of the type along Rattlesnake Creek is nearly level, having a very slight slope downstream. The extensive area is flat and undrained. It probably represents the subsidence of strata into the cavity left by dissolved salt beds.

Utilization.—The accumulation of salt in the soil and the large amount carried by the soil waters render the Salty Marsh unfit for farming. It is used for grazing or as native hay meadows. The coarse grasses yield a good quantity of hay, which sells at $8 to $12 a ton.

AGRICULTURE.

EARLY HISTORY.

As elsewhere on the Great Plains, stock raising at an early date became the principal industry in western Kansas. A region covered by nutritious grasses was an inviting field for the cattlemen, and the hostile Indians were not subdued before a large part of the region was utilized for grazing. Winter losses occasionally depleted the herds, but in ordinary years the climate was favorable and the business profitable for the comparatively small number engaged in it. In addition to the herds raised in Kansas, many thousands of cattle were driven up from the southwest along the old Santa Fe trail to be finished on more nutritious northern grasses. The cattlemen were not permitted to remain in undisturbed possession of the country very many years, though the industry has persisted to a greater or less extent to the present time.

Farming began in western Kansas sooner than in the other States of the Great Plains having the same general conditions, and so rapid was the advance of the farmers in the early eighties that by 1887 there was hardly a productive and conveniently located quarter section of land in the State that was unoccupied. Abundant crops in 1885 had given encouragement to the new settlers and established a faith in the country that a return to normal climatic conditions proved was not justified. To add to the misfortune of the pioneers,

who in average years would have found conditions hard in a region of scanty rainfall, the country was now visited by a series of extremely dry years. Partial crop failures were general in 1886 and 1887, though the immigration encouraged by the earlier successes was hardly checked; but in the period from 1889 to 1893 unusually severe droughts, combined with other difficulties, so impoverished the new settlers that a large part of the western half of the State was almost depopulated.

The reasons for the failure of the homesteaders can not be ascribed entirely to climatic conditions. The settlers themselves were not fitted by experience nor equipped with implements and capital to overcome the difficulties of a semiarid country. Wheat, corn, and oats were grown from the first, but seed brought from the east had been bred in the humid regions and drought-resisting varieties were unknown. The elementary principles, at least, of moisture conservation by proper cultivation are now generally adopted by the farmers of this region, but at that time none of the so-called "dry-farming" methods were practiced, so that dry weather did much more damage than droughts of longer duration would do at the present time. Another factor of great importance was the poverty of these early immigrants. They had not capital needed to farm in a region of uncertain yields, so that the loss of one crop brought many of them to the verge of starvation. To the financial difficulties that beset the people of the region was added the general depression throughout the country and the consequent low price of all agricultural products. This combination of misfortunes caused a general exodus of the farming population and most of the land was again left to the cattlemen, who bought large tracts of it at very low prices. This depression extended over the entire western half of the State, but it was much more severe in the western two tiers of counties, decreasing in its injurious effects toward the east. East of the one-hundredth meridian, which passes near Dodge City, the average crop yields were sufficient to maintain the population, and though there was some loss of people, the country was soon resettled, and as the seasons became more favorable the settled areas gradually extended toward the west.

Beginning about 1898 there were several years of well-distributed rainfall, good crops were made, and farmers again made use of the land. This advance of settlers, which has continued to the present time, has been much more successful. They are now bringing with them knowledge of scientific agriculture applicable to the plains, and with drought-resisting crops and capital to withstand several failures if necessary, they have a much greater chance of success than the early pioneers.

The Russian wheats were introduced in Kansas about the time the first farmers came in, but it was many years before the farmers were supplied with seed. The introduction and improvement of these and other hardy and drought-resisting plants has contributed in no small degree to success in farming on the semiarid plains. It was found that alfalfa would grow along the stream valleys even to the extreme western part of the State, and soon thousands of acres of this valuable forage gave stability to the agriculture of the region. The introduction of kafir and milo maize furnished forage and grain crops for the upland that grow in favor year by year. It is a rare occurrence for both kafir and small grains to fail in the same year, so that the uncertainty of depending upon wheat alone is eliminated.

Fluctuations have occurred from time to time in the advance of population, and droughts have caused hardships in some localities. Some of the western counties have never regained their former population, but rapid settlement has been made in the last 10 years over the entire area.

RANCHING.

Ranching, once the principal occupation of the region, has fallen to occupy a minor place among the industries. Cattle are ranged by small owners over the sand hills south of the Arkansas River and on a few large ranches in the southern part of the State. The latter vary in size from 4 or 5 sections to 25 or 30. They were established when land was cheap and should have been broken up long ago, as those which contain level farming land have enhanced in value to a point where it is no longer economical to use them for grazing. They have been held for still higher prices. The time, however, must soon come, if the present prosperity of the region continues, when they will be subdivided. The high price of meat animals of late years has tended to delay this change from ranching to farming.

The ranches are for the most part well watered. The cattle grown are usually grade Herefords, though the Angus, Galloway, and Shorthorn breeds are represented. The old method of extensive grazing on the plains is doomed to extinction, but a modified form of stock raising combined with dry farming or along the streams with irrigation may yet prove a permanent feature of the future agriculture of the Plains Region.

PRINCIPAL AGRICULTURAL PRODUCTS.[1]

Among the great variety of crops that are grown in western Kansas the most important are wheat, corn, oats, barley, kafir, milo maize,

[1] The statistics used in this chapter were taken from Report of the Kansas State Board of Agriculture, Quarter ending December, 1910.

sorghum, alfalfa, broom corn, sugar beets, emmer ("speltz"), and Irish potatoes.

Wheat.—Wheat is the great money crop of western Kansas, and there is no doubt that it will hold this place in the agriculture of the region for many years to come. (Pl. XVI, figs. 1 and 2.) The reasons for this are that it is the best crop for a system of extensive farming, as one man can handle so large an acreage, and that it can always be readily sold for cash at a good price. During the present season (1910) nearly 3,500,000 acres in the present survey were planted to this crop, and a total of 41,835,984 bushels were produced. There were 14 counties in which the yield exceeded 1,000,000 bushels, and in one county—Pawnee—it was almost 4,000,000. The average yield in the eastern part is almost 14 and in the western 8 bushels. Wheat does not resist drought in the manner that the sorghums do, by remaining dormant in periods of dry weather, but certain varieties seem to be more hardy than others, and make much larger average yields under semiarid conditions. In the last few years crops have been greatly increased on the plains by the introduction and general use of the hardy varieties and by careful timing of the growing season so as to have the crop come on in time of probable rainfall.

Spring wheat is not so well adapted to the Kansas climate as the winter-sown varieties and is now little grown except in Cheyenne, Sherman, and a few other northern counties, where for some reason it has held a place, but even there the acreage is steadily decreasing. The preference of the wheat grower for the winter wheats is due to the fact that it is possible to conserve moisture enough in ordinary years to germinate the wheat and give it a good growth, which will hold the soil and prevent the blowing away of the land by the strong winds of March and April. The hard red varieties of winter wheat have been found best suited to the soils and climate of western Kansas. The "Turkey" wheat was introduced into the State about 25 years ago from Russia, but it was many years before it was widely distributed. Gradually this and other new varieties of similar characteristics have become the main reliance of the wheat growers. The United States Department of Agriculture has brought several hundred varieties from Russia, Siberia, and other countries, and they have been tested by the various State experiment stations. As is usually the case with such importations, only a very few were found to be of real worth when tried under changed environment.

During the past few years great interest has been shown by the farmer in improved varieties of wheat, and the experiment stations, in addition to making test of new varieties, have supplied some of the more promising to the farmers at a reasonable price. Besides the better known wheats, Kharkof, a red winter wheat of the bearded Turkey type, has met with a favorable reception and is

widely distributed over the State. It produces well in the western part of the State and will probably become the leading variety in this section. The Ghirka is the only beardless wheat that has proved successful for western Kansas. It yielded as well as the Kharkof in the test made at the State experiment farms. The grain is smaller than that of the Kharkof, but is of good color and quality. From reports received by the station it is certain that these Kharkof and Turkey Red strains sent out by the station are superior in yield and quality to the ordinary Turkey Red grown in the State. The improvement of wheat, however, has only begun and constant improvement may be expected in hardiness and productiveness.

Other small grains.—Oats are grown in all parts of the area, but most extensively in the eastern one-third. This crop does not withstand dry weather very well and is therefore not well suited to the semiarid western part of the State.

Barley is of almost equal importance with oats as a small grain crop and in some sections ranks above it. The largest acreage occurs in Thomas, Rawlins, Sherman, Cheyenne, Wichita, and Decatur Counties, which had from 15,000 to 45,000 acres planted to this crop in 1910. Some rye is sown, principally in Rawlins, Ford, Gray, and Hodgeman Counties, none of which, however, had more than 1,500 acres.

Emmer ("speltz") constitutes quite an important crop in the western part of the State, particularly in Gove, Logan, and Sheridan Counties. This crop withstands drought better than most of the small grains and should prove valuable for this section. A considerable acreage is also planted to millet.

Corn.—Corn is grown to some extent in every county in Kansas, but the yield varies widely as we go from the eastern to the western parts of the State. In the eastern two tiers of counties corn is grown extensively and profitably, but in the western counties the average yield would seem to be too low for profit. In this section it is probably grown more as a convenience for use on the farm than as a money crop. The Yellow Dent is the most popular on the plains.

Corn is grown on both the heavy and sandy soils, the former giving best results in seasons of favorable moisture and the latter in drier years. On an average the sandy soils probably give the largest returns. This is due to their porous nature, which allows the rainfall to enter and pass down into the subsoil, where the corn roots can secure it.

Kafir, milo maize, and sorghum.—No other crops have done so much to put the agriculture of this area on a safe basis as the nonsaccharine sorghums, of which the most valuable are kafir, milo maize, and sorghum or cane. The great value of these crops is due

to the fact that they have their growing season in time of the greatest probability of rain and also that they withstand drought and hot winds more successfully than any other crops of the region. They belong to that class of plants that have the power of remaining dormant during the dry season and resuming their growth when moisture is again supplied.

Kafir and milo maize are both widely grown, the acreage devoted to the former being five or six times as great as that of the latter. Each has its place in the system of agriculture practiced on the plains. Kafir is more generally grown for forage, as it has a large proportion of leaves that are palatable, while milo maize is more often planted for the grain, as it bears a large head and is more certain to make a crop, being more drought resisting than the kafir. When cut for the grain very little of either of these crops is thrashed, as it is just as convenient to feed it on the farm in the head. The yield of maize in the most favorable seasons is from 25 to 50 bushels, while the yield of kafir under the same conditions would be about 20 to 30 bushels. These maximum yields, however, are seldom realized, for while these crops are called drought resisting because of their power to remain dormant, a very long continued drought or a lack of rain during the entire season cuts the yield short and in extreme cases causes an entire failure. Average yields of grain are hard to estimate, as all figures available give the production in terms of tons of dry forage. From the statistics collected by the State department of agriculture for many years it seems that the yields range from about 3 tons of fodder in the eastern counties to 2 tons in the western counties.

There is no well-established market for the grain, but so far no inconvenience has been experienced from this fact, as nearly all the grain produced has been needed on the farms and any small surplus could be sold in the locality. The popularity of the grains will increase in time as the high feeding value is recognized. It can be used to take the place of corn in a system of stock farming, and can be grown more cheaply than corn on the plains.

Sorghum is also extensively grown, especially in the western part of the area, the total acreage probably being greater than the combined acreage of kafir and milo maize. Logan and Scott Counties had the largest area, but much land is planted to this crop in other counties, particularly in Hodgeman, Gove, Lane, Ness, Finney, Thomas, and Norton Counties. Where grown for seed the ground is usually listed, the seed drilled in rows and cultivated, but when grown for forage, as most of it is, it is sown broadcast or put in with a grain drill. Sorghum is one of the most valuable crops for this section, 2 to 3 tons per acre being about the average secured. (Pl. XVII, fig. 1.)

Alfalfa.—Of the forage crops, alfalfa is by far the most valuable wherever it can be grown to advantage. In nearly all parts of the area it is confined to the stream valleys, where there is subirrigation near enough to the surface to be reached by the roots of the plant, or to small areas that can be irrigated from streams or wells. As the valleys become narrower and water scarcer toward the western part of the State the acreage in alfalfa decreases. The largest proportion of alfalfa is grown in the eastern counties, which are also best adapted to corn, and the two crops make a useful combination for general farming. The yield of hay in the best districts is more than 4 tons to the acre. In the western part of the State the yield of hay is reduced to about 2 tons, but here a good yield of seed can be secured and much is grown for this purpose. The second or third cutting is allowed to seed and the yield ranges from 4 to 9 bushels. Alfalfa hay is valued at from $5 to $7 a ton and seed of good quality brings from $9 to $10 a bushel.

Alfalfa is not grown on all land to which it is adapted, as some farmers consider other crops more profitable. It is doubtful, however, if it is not better in the long run for a farmer to have at least a part of his farm in alfalfa even if other crops in good years seem more profitable.

Broom corn.—Broom corn has been grown in some sections for a number of years, but its production has been greatly increased recently. The good crop and high price in 1909 caused a decided increase in the acreage during the present season. Kearny, Stevens, and Hamilton Counties had the largest acreage in 1910, but much is grown also in Seward, Grant, Stanton, Morton, Cheyenne, Finney, Wallace, Meade, Scott, Wichita, and some other counties. The total area amounted to 97,872 acres.

Two varieties are grown—the standard and dwarf. The majority of the farmers seem to prefer the dwarf, as it is less expensive to handle, has a slightly better quality of brush, and furnishes more and better forage. However, the dwarf must be harvested within a short time after ripening or it will turn red and deteriorate in value. The standard, on the other hand, may be harvested over a more extended period.

While broomcorn is grown upon both sandy and heavier soils, the yields are surer on the former, especially in dry years.

Sugar beets.—Within the last few years, or since the construction of the large beet-sugar factory at Garden City, sugar beets have become an important crop in Kearny and Finney Counties, particularly in the section between Garden City and Lakin. In 1910 the total acreage in the entire survey was 8,072, of which all except 40 acres was in the above two counties. The acreage was considerably less than in the previous year.

The company which erected the sugar factory controls about 12,000 acres of land, on which most of the beets are grown. A large reservoir has been constructed by this company for storing water, secured from the Arkansas River during floods or from the underflow by pumping. The farmer must agree to plant beets before the company will rent him the land and furnish water. The rental for beets is one-sixth, and the farmer pays for the water in addition. A number of farmers have small plants and pump their own water from the underflow, and the consensus of opinion seems to favor this system as being most satisfactory.

Beets yield on an average about 10 tons to the acre, and the farmer receives $5 per ton. The cost of raising is estimated at about $35 per acre. This would leave a profit of $15 per acre to the grower. Owing to the hard work involved in growing this crop it is not very popular with the farmers.

Experience has shown that sugar beets give the best results on the loam and silt loam soils. In the valley the Laurel loam and on the uplands the Richfield silt loam are the soils upon which the most profitable yields can be secured.

AGRICULTURAL METHODS.

The principal question involved in tillage on the Great Plains is that of the conservation of moisture in the soil. While much attention is being given to the selection of varieties suited to the semi-arid belt, it is very doubtful if any crop will succeed in extremely dry years. Some varieties are more hardy and drought-resisting, but no plant will grow if the moisture in the soil is reduced below a certain point. It is on thorough cultivation, therefore, that the farmer of western Kansas must rely for success. In seasons of unusual rainfall crops will yield well with only ordinary care, while in very dry years the best methods are unavailing. This fact has seemed to discourage some farmers from employing the best methods, as they reasoned that the careless preparation of the land being cheaper a greater acreage might be cultivated and the profits would be larger in the long run. All careful experiments, however, have demonstrated that the better preparation of the land is profitable. The problem in this section is not to be decided by the results obtained in good or in bad years, but success must be attained by bringing up the average crop to exceed the average cost. This can only be done by a reasonable amount of care in the preparation of the land to conserve the soil moisture.

There is no hard and fast method of so-called dry farming that may be applied in all seasons and on every kind of land, but there are general principles of moisture conservation that may serve as a

guide. The farmer himself must constantly study the conditions that confront him and familiarize himself with the peculiarities of his soil. In no section of the country is a study of the soil of more importance, and this survey has been undertaken to gather all the general information possible that the United States Department of Agriculture and the State experiment stations may more intelligently advise the farmer as to the best cultural methods for his soil.

There are many variations in the so-called "dry-farming" methods, but in all of them the essential features are thorough preparation of the land and the maintenance, as far as conditions permit, of the dust mulch on the surface to prevent evaporation. Methods must always be varied to suit climatic conditions and the character of the soil and it is for this reason that a study of the texture and structure of the soil is so important.

On sandy lands deep plowing is not necessary, as the soil is naturally porous and sometimes needs to be compacted rather than loosened, especially for small grain. These soils often blow rather badly and it is well to leave the surface rough and run the rows east and west. If weeds are kept down there is usually sufficient shifting of the surface material to form a mulch so that cultivation is not so essential as on the heavier soils. In case of the latter soils deep plowing so as to loosen up the subsoil and thus enable the rainfall to enter is very essential.

A rather rough surface will aid in preventing the water from running off during heavy rains. A crust usually forms on the surface and cultivation after rains, to make and maintain a dust mulch, is necessary. The soil, however, should not be pulverized too fine else the first drops of rain will puddle the surface and cause a large percentage of the rain to run off.

It is claimed by practically all the farmers that the sandy lands withstand dry weather better than the heavier soils, which seems very peculiar to one accustomed to humid conditions. There are several reasons, however, why this is true. The sandy soils are much more porous and a much larger percentage of the rainfall therefore enters the soil instead of running off, as is the case in the silt loams and other heavier soils. This emphasizes the importance of loosening the heavier soils so that the rainfall can easily penetrate them. The heavier soils also require a larger amount of rainfall than the sandy to wet them to the same depth, while the crop can not draw out as large a percentage of the moisture. These and other reasons make crops more certain in dry years on the sandy soils than on those of heavier texture.

In nearly all parts of this area the seed bed should not be made too mellow and loose, for two reasons: (1) Because there should be a firm stratum of earth below the seed to establish capillarity with

the moisture below, and (2) because if the soil is brought into too loose condition it is subject to blowing by the spring winds. The subsurface packer is used successfully on some soils to form the capillarity stratum below the surface, but in many soils this may be accomplished by the ordinary plowing and disking.

In the preparation of land for crops in western Kansas, three general methods of breaking are practiced—plowing, listing, and disking. There is no fixed rule for the use of either method or for the time of operation. Early or late plowing and shallow or deep, single or double listing are practiced by different farmers, or the processes may be alternated in successive years. Much depends upon the opinion of the farmer as to the best method, his resources, the character of his land, and the amount of moisture in the soil in any particular season.

It is hardly to be questioned, all conditions being normal, that plowing is by far the best preparation that can be given for the conservation of moisture later in the season. Good farmers who practice the other methods recognize the fact that land should be plowed at least every two or three years. The best time for plowing depends upon the character of the soil and the amount of moisture it contains and must be determined by the farmer. At the State experiment station at Manhattan the land plowed about August 15 gave the highest yields, but in the western part of the State land is usually broken as soon as possible after harvest. Breaking is usually done by gang plows, drawn either by four to six horses or by a steam or gasoline traction engine. (Pl. XVII, fig. 2, and Pl. XVIII, fig. 1.)

The usual depth of plowing is from 4 to 5 inches, but occasionally a depth of 7 inches is reached. To prepare the land well it is harrowed twice before seeding.

Those who practice listing (Pl. XVIII, fig. 2) justify it on the grounds that: (1) It is a quicker method, and the farmer who is pressed for time is able to seed a larger acreage; and (2) that it leaves the surface in ridges, which check the blowing of the soil. The ridges are left until after thrashing, when they are sledded down and usually harrowed with a dog-toothed harrow before seeding.

Disking is often resorted to when the land is so hard that it can not be listed nor plowed. Much of the disking is done immediately after harvest.

At the experiment station at Manhattan land prepared by disking gave a two-year (1908–1909) average of 21.5 bushels of wheat; double disking, 25.3 bushels; by summer plowing, 31.9 bushels; summer plowing 7 inches deep, 34.5 bushels; and by summer listing, 26.7 bushels.

TENURE AND SIZE OF FARMS.

Nearly all the land now farmed in western Kansas was homesteaded and patented many years ago. The changes that took place in land ownerships during the subsequent dry years have already been described. The original quarter sections of many of the early settlers were coalesced into large holdings by cattlemen or by farmers, who remained in the country. During the last few years, since farming has been resumed even to the western edge of the State, there has been a steady breaking up of the large tracts, as the holders were losing more in interest on high-priced land than they could gain in the cattle business.

In the eastern part of the area the acreage per capita for the actual residents ranges from 50 to 100 acres, while in the extreme western counties large holdings are the rule, and the average is from 100 to 500. In the latter section only a very small proportion of the land is farmed. Much of it is held by nonresidents or those living in the neighboring towns. While the tendency is toward a reduction of large holdings, land in the western counties will never be subdivided to the same extent as in the eastern part of the State. Extensive farming or farming combined with stock raising will probably always be the best systems of agriculture for this region.

LABOR.

The usual scarcity of labor experienced throughout the Western States is felt here. The farmers in the eastern part of the area, who do general farming and dairying, have need of labor at all seasons, and many keep a man hired by the month. Others with well-kept farms keep no hired man, but do their own work with the help of extra labor in the busy seasons. In the western part of the State the grain farmers do not need labor except in harvest time, when it is in great demand. For harvesting and thrashing as high as $3 a day with board may be offered. Some of the thrashing crews are paid according to the amount of grain thrashed, usually 20 cents per man for every 100 bushels. These prices attract labor and raise the price of help to the farmer. Some of the farm work is done by contract. Corn is husked by the bushel, 3 to 5 cents being paid, depending upon the scarcity of the ears.

The labor is usually of fair efficiency. The workers are usually from the farms, where work is not pressing, or men from the towns, familiar with farm work. Mexican labor is brought in and employed by the railroads, and it is sometimes hired by the farmers for such work as harvesting broom corn or sugar beets.

IRRIGATION.

Irrigation plays a minor part in the agriculture of Kansas when the total production is taken into consideration, but it is important in limited areas, as it makes profits sure in the driest years and adds to the list a number of crops that could not otherwise be grown.

There are two sources of supply for the water employed in irrigation—streams and wells. The Arkansas is more heavily drawn upon than any other stream, but it is the subsurface flow that is most used, as the surface flow is uncertain. The underground supply is tapped by shallow wells and projects of considerable size, as well as many small farms, are watered. The largest user of water is the company controlling the sugar industry at Garden City, which irrigates nearly 10,000 acres of beet land in a single tract. Numerous small plants, owned in most cases by individual farmers, irrigate a considerable total acreage in the valley. Over a large part of the valley water stands at a level of about 10 feet below the surface, and is easily and cheaply lifted by the small pumping outfits, which use gasoline engines for power.

There has been much discussion as to how much the flow of the Arkansas will be affected by the drafts upon it at different points along its course, and there is still litigation between the States of Kansas and Colorado as to the use of the water.

Numerous small streams in different parts of the State are used, but only crudely, as in flooding the land immediately below a reservoir.

Deep wells have been a source of water for irrigation in recent years. For a long time local artesian basins were tapped and the flow used to some extent for irrigation, but only on a small scale, as the supply was too small to cover any large acreage. During the last few years the country around Scott has proved to be an adequate artesian basin and several wells have been brought into service. The supply of water is sufficient to irrigate good-sized areas, but in most cases the wells are expected to cover more ground than they can water in very dry seasons. A well recently sunk at Richfield, in Morton County, is reported to have produced a flow of about 1,200 gallons per minute. If the field proves to be very extensive, settlement will be greatly encouraged in the southwestern part of the State. Several wells occur in the Artesian Valley and are used to some extent in irrigation.

ALKALI.

In all arid and semiarid regions soluble salts are released from disintegrating rocks faster than they can be removed by leaching with the limited amount of water, and there is danger in some localities where conditions are favorable that alkali may be concentrated

in amounts dangerous to plant growth. In western Kansas this takes place only where drainage is restricted and there is great evaporation and concentration or on irrigated land where the capillary movement of soil water accelerates the accumulation. Where water passes through the soil it takes a portion of the soluble material into solution, and when the water is brought to the surface and evaporated the salts are left behind. The latter process has caused a concentration of alkali on the irrigated land, particularly in the Arkansas Valley. The accumulation by evaporation from areas of restricted drainage may be noted in various depressions in different parts, but the best examples are in White Woman Valley north of Garden City. The alkali problem in the vicinity of Garden City was discussed by Burgess and Coffey as follows:

The area as a whole is free from harmful amounts of alkali. However, the heavier soils of the lowlands contain sufficient salt to become harmful if extensive flooding of the uplands should be practiced. But since economical irrigation does not permit of seepage water, these lowlands should not only remain out of danger from upland irrigation, but what little salt they do contain should be and can be eliminated by cultivation. Out of more than a dozen borings and other tests we failed to find in the worst localities a salt content of more than 0.70, and the average quantity was 0.324 per cent. These borings were taken where the indications of alkali were most pronounced and where it is most likely to be found—that is, on the heavy soils of the lowlands along the river and in the depressions on the uplands. The most important alkali district in the area is found in the depression of the White Woman Valley, east of Garden City. On some of the lower levels of this depression there may be seen a white efflorescence of salt during the dry season. Salt grass covers the depression generally, but the percentage of salt is not large enough to interfere seriously with agriculture. Where the soil is thoroughly cultivated the salt grass and other indications of salt disappear. A great deal of this White Woman Valley in this area is used for pasture, and when the salt grass is young it gives good grazing. The remainder of the valley is sown to sorghum, macaroni wheat, etc. These both do well and are not injured by the quantity of salt found in the soil there. As stated above, other places in the area have some alkali, but not of sufficient concentration to injure crops in a noticeable degree, except in occasional local spots. The part of the area where the accumulation of alkali is most likely to occur is that part which lies immediately under the low bluff line between Sherlock and the Point of Rocks on the north side of the river. There is not a serious amount of alkali here yet, but irrigation will have to be carefully and economically practiced in order to keep the salt in the lower and heavier strata of soil where it is at present. There is not very much of this strip, and it can be, and should be, controlled by methods of cultivation which tend to lessen the total amount of evaporation from the surface of the soil. For the management of this strip of heavy soil deep cultivation, flooding with the annual flood waters (not with the underflow water), and subsequent mulching to about 3 inches to prevent evaporation is recommended. Probably the best crops to be grown on this soil are sorghum and sugar beets, both of which tend to rid land of small amounts of alkali.

There is a small amount of alkali in the immediate river bottom in the Laurel loam. The average content is very low, however, and there does not seem to be any reason to expect serious trouble there.

SUMMARY.

The soil reconnoissance of western Kansas described in this report covers the 46 counties, which lie west of the meridian of 98° 30′ west longitude, and comprises a total area of 39,960 square miles.

Physiographically it is a part of the vast plateau known as the Great Plains, which slopes gently eastward from the Rocky Mountains and is built up of débris or outwash from the Rocky Mountain uplift.

There have been many changes in the agricultural prosperity of the region, due to drought, and the farming population has fluctuated in numbers, particularly in the extreme western part. At the present time the population is increasing rapidly. There are no large towns in the area. Several railroads, running principally in an east and west direction, furnish transportation facilities.

The entire area lies in the belt of deficient rainfall, and droughts must be reckoned with, particularly in the western counties. Strong winds and a dry atmosphere favor rapid evaporation. In spite of these difficulties, dry farming is carried on with some success in all parts of the area and very profitably in the eastern part.

The greater part of the area is covered by four silt loams which resemble each other so closely that the line of separation between them in most places is entirely arbitrary. One of these, the Colby silt loam, is derived from the loess; another, the Richfield silt loam, from a Tertiary silt deposit known as Plains Marl; the third, the Greensburg silt loam, is a more weathered phase of the latter; and the fourth, the Summit silt loam, is derived from calcareous shales of the Cretaceous. The lower members of the Tertiary have given rise to several sandy types, all of which have been influenced by wind action. Along many of the stream courses there are extensive rock outcrops which have partially weathered into several stony loams, varying according to the character of the original rock. The alluvial soils of the Arkansas have a wide range of texture and are characterized by sandy or gravelly subsoils. In most places these bottoms have effective subirrigation, and there are several irrigation projects in operation.

On these soils a wide variety of crops are grown, including cantaloupes, sugar beets, and alfalfa. The alluvial soils of the smaller streams are valuable as alfalfa land.

Land values in the area are constantly increasing, and the cattle ranches are being broken up into smaller tracts for farming purposes. The principal agricultural products are wheat, corn, oats, alfalfa, kafir, milo maize, hay, potatoes, broom corn, melons, barley, rye, apples, and other fruits and truck crops.

The price of land varies from $3 to $10 for the grazing land to $10 to $100 for farming land. The irrigated and subirrigated alluvial land commands the highest price. There is very little land suitable for dry farming that can be bought for less than $10 an acre.

In the eastern part of the area the agricultural future is assured under present methods, but toward the western boundary of the State success will only be attained by careful planning, economy, and the use of the most scientific methods of dry farming.

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