

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE KANSAS STATE AGRICULTURAL COLLEGE,
H. J. WATERS, PRESIDENT; KANSAS AGRICULTURAL EXPERIMENT
STATION, W. M. JARDINE, DIRECTOR; L. E. CALL, AGRONOMIST.

SOIL SURVEY OF COWLEY COUNTY,
KANSAS.

BY

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AND B. W. TILLMAN.

H. H. BENNETT, INSPECTOR, SOUTHERN DIVISION.

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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., October 25, 1916.

SIR: I have the honor to transmit herewith the manuscript report and map covering the survey of Cowley County, Kans., and to request that they be published as advance sheets of Field Operations of the Bureau of Soils for 1915, as provided by law.

The selection of this area was made after conference with State officials cooperating with the bureau in the work of surveying the soils of Kansas.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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MAP.

Soil map, Cowley County sheet, Kansas,

BUREAU OF SOILS.

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SOIL SURVEY OF COWLEY COUNTY, KANSAS.

By E. C. HALL, In Charge, R. H. HALL, and B. W. TILLMAN.—Area Inspected by HUGH H. BENNETT.

DESCRIPTION OF THE AREA.

Cowley County, Kans., is situated in the southeastern part of the State, bordering the Oklahoma State line. It is bounded on the north by Butler County, on the east by Elk and Chautauqua Counties, on the south by Osage and Kay Counties, Okla., and on the west by Sumner County. Cowley is one of the larger counties in the State and has an area of 1,133 square miles, or 725,120 acres.

Cowley County lies in the Great Plains region of the United States. The country is treeless, except for narrow fringes of timber along the streams. The surface of the upland, comprising over 75 per cent of the area of the county, is predominantly undulating or gently rolling. In the eastern part of the county, the Flint Hills section, the surface is characteristically rolling. There are here many rather deeply cut valleys and narrow, ridgelike, steep-sloped divides, which, however, usually have level or nearly level tops.

In many parts of the county there are level or faintly undulating areas, some of which are several miles in width. These level lands occur (1) over the higher situations, as in the vicinity of Atlanta and in the southwestern part of the county, and (2) in relatively low areas bordered by higher undulating country, as in the vicinity of Grand Summit and south of Eaton. Small areas in which the surface appears to be perfectly level are encountered here and there throughout the county, as 3 miles south and 4 miles west of Arkansas City, about 6 miles northwest of Winfield, 3 miles north of Udall, and in the vicinity of Atlanta.

The larger streams have cut valleys whose floors lie 25 to 200 feet or more below the upland level. The deepest valleys are developed in the eastern part of the county, as along Otter Creek. Here the steepness of the valley walls is accentuated by the narrow ledges of cherty limestone common to the Flint Hills section. The slopes between the uplands and the bottoms of the broad and comparatively shallow valleys, such as those of the Walnut and Arkan-

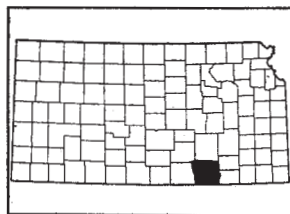


FIG. 1. — Sketch map showing location of the Cowley County area, Kansas.

sas Rivers, are usually gentle, while the slopes to the narrow smaller valleys, as along Grouse, Crab, Otter, Rock, and Silver Creeks, are steep to precipitous. On nearly all the slopes bedrock frequently outcrops and the soil is usually thin. Generally rock outcrops appear immediately along the upper part of the break from the upland to the valleys, the rock appearing with a regularity suggestive of its having been artificially placed. Below this upper exposure there are often one or two other lines of outcrop on the slopes; these, however, are not everywhere so nearly continuous as the exposure above. There are occasional outcrops of rock in the level uplands, and bedrock is frequently reached within the 3-foot section, particularly in the eastern part of the county.

Topographically the uplands are well suited to the use of the most improved farm implements, except on the sloping areas, where rock outcrops are especially numerous; here cultivation can be performed only with difficulty, if at all. The valleys are mostly broad bottomed, the width varying with the size of the stream. The valley floor surface is in general level or very nearly so. There are, however, some hummocky, sandy areas in the Arkansas River bottoms. Much of the bottom land is subject to overflow. Inundations, however, are not frequent, and practically all the bottom land can be cultivated.

In elevation above sea level Cowley County ranges from 900 feet, in the southeastern part along Rock Creek, to a maximum of about 1,500 feet, reached at several places in the northeastern corner. The general elevation of the county is between 1,150 and 1,300 feet above sea level. The approximate elevations above sea level of some of the towns are as follows: Winfield 1,124 feet, Arkansas City 1,173 feet, Udall 1,281 feet, Atlanta 1,430 feet, Burden 1,375 feet, Dexter 910 feet, Grand Summit 1,438 feet, and Maple City 1,255 feet. The general slope of the county, as indicated by the flow of the larger streams, is southwesterly.

The Arkansas River, which crosses the southwestern part, receives most of the surface drainage of the county. This river has a rather wide, shallow channel and a sluggish current. Its principal tributaries are Walnut River and Grouse and Spring Creeks. These streams have a swifter current than the Arkansas River and are eroding their channels rather actively. The eastern part of the county is drained by Otter, Cedar, and Rock Creeks and their tributaries. All these streams have carved wide, deep valleys, whose sides in many places are steep to precipitous. There are many smaller streams, branches, and intermittent drainage ways throughout the uplands, forming a comprehensive drainage system which reaches all parts of the county. All the first-bottom lands are subject to overflow, but inundations do not occur regularly each year.

Cowley County was formed by an act of the Kansas Legislature in 1867. The 1910 census reports the population of the county as 17,582. Over 55 per cent of the population is urban. The rural population is well distributed over the western and central parts of the county; the eastern part is less thickly settled, on account of the rougher topography, and large tracts of land are used solely for the grazing of stock.

Winfield, the county seat, with a population of 6,700, is situated in the west-central part of the county, on the Atchison, Topeka & Santa Fe and Missouri Pacific Railways and the St. Louis & San Francisco and the Southwestern Interurban Railroads. Arkansas City, with a population of 7,508, is situated in the southwestern part of the county. It is a railroad town of some importance and carries on a large trade with the surrounding country. Dexter, with a population of 512; Udall, with 330 inhabitants; Atlanta, with 330; and Burden, with 424, are towns of local importance, and there are several other smaller towns distributed throughout the county.

Transportation facilities are good, except in the extreme southeastern part of the county. The Atchison, Topeka & Santa Fe Railway extends through the western part in a north-and-south direction, passing through Udall, Dale, Winfield, Hackney, and Arkansas City. Other lines of this system extend north and east from Winfield. The St. Louis & San Francisco Railroad between Beaumont Junction, Kans., and Enid, Okla., crosses the county southwesterly, passing through Atlanta, Wilmot, Floral, Winfield, and Arkansas City. The Missouri Pacific Railway passes through about the central part in an east-and-west direction. These lines furnish excellent freight and passenger service. Chicago, Kansas City, Wichita, St. Louis, and Denver constitute the principal markets for the products of Cowley County. The exports consist principally of live stock, alfalfa, and prairie hay.

The wagon roads of the county are in good condition the greater part of the year. In the eastern part, where much of the land is rough, the roads are poor. All parts of the county are reached by rural mail delivery service, and telephones are in general use throughout the rural districts.

CLIMATE.

Cowley County has a mild climate the greater part of the year. There is a wide range, however, in temperature. The coldest winter weather is usually caused by high winds, known as "northers," and is of short duration. In general the winters are mild, though severe ones occasionally occur. The lowest temperature recorded is -27° F. In some years wheat winterkills. The summers are usually long and at times the temperature is high. Dry periods sometimes occur, accompanied by hot winds, which, though of short duration,

are damaging to growing crops. Temperatures of 100° F. or higher often occur. The mean annual temperature as recorded at Winfield is 56.5° F.

Frosts begin about the last of September or the middle of October, and in the spring they sometimes occur as late as the middle of May. The average date of the last killing frost in the spring is April 19 and that of the first in the fall October 15. This indicates a normal growing period of about 180 days, which is long enough for the maturing of all the common crops.

Cowley County is situated in the region of moderate rainfall. Many hot, dry summers occur, but droughts are seldom so severe as to cause a complete crop failure. On the other hand, in some years the rainfall is amply sufficient for the production of all the crops grown. The rainfall in the summer of 1915, the heaviest in years, was so abundant as to do much damage to growing crops and to the maturing wheat crop. The average yearly rainfall is about 30 inches. The spring and summer months are usually the wettest.

Light snows are common in the winter months, but snow rarely remains on the ground for any long period. The average yearly snowfall is reported as 6.7 inches.

Hailstorms sometimes occur and often do great damage over small areas, as was the case in the summer of 1915.

The prevailing winds are from the south. Winds of high velocity are common in the winter and spring, sometimes doing considerable damage on the looser soils, of sand and sandy loam texture.

The following table gives the normal and extreme monthly, seasonal, and annual temperature and precipitation as recorded by the Weather Bureau station at Winfield:

Normal monthly, seasonal, and annual temperature and precipitation at Winfield.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December.....	33.8	72	- 8	0.98	0.58	0.05	1.4
January.....	32.6	70	-15	1.01	.50	.33	1.4
February.....	32.3	76	-27	1.24	.94	4.10	2.4
Winter.....	32.9	76	-27	3.23	2.02	4.48	5.2
March.....	48.2	92	9	1.64	1.04	2.40	0.7
April.....	56.9	94	24	2.96	3.61	3.82	Trace.
May.....	65.8	100	26	5.04	2.42	8.16	.0
Spring.....	57.0	100	9	9.64	7.07	14.38	.7

Normal monthly, seasonal, and annual temperature and precipitation at Winfield—Continued.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
June.....	74.5	108	42	2.78	1.94	10.95	.0
July.....	78.6	114	51	4.07	2.49	3.26	.0
August.....	79.3	112	45	3.08	1.24	3.20	.0
Summer.....	77.5	114	42	9.93	5.67	17.41	.0
September.....	70.7	104	30	3.24	2.74	3.23	.0
October.....	59.4	100	22	2.39	1.75	3.70	Trace.
November.....	46.1	83	6	1.71	1.48	3.60	.8
Fall.....	58.7	104	6	7.34	5.97	10.53	.8
Year.....	56.5	114	-27	30.14	20.73	46.80	6.7

AGRICULTURE.

During the early settlement of Cowley County little farming was carried on. The settlers subsisted largely by hunting, trapping, and trading. When the country was opened for homestead entry many immigrants came from Illinois, Indiana, Ohio, Iowa, Pennsylvania, and Missouri. The first farmers settled along the Walnut River and cleared small fields in the bottoms, upon which they grew some corn and wheat. Stock raising early became of importance. The cattle were raised and fattened largely upon the range, then driven to Kansas City to be sold. After the construction of railroads the production of crops and the number of cattle raised increased rapidly.

The table below gives the acreage and production of the principal crops for the census years 1880, 1890, 1900, and 1910:

Acreage and production of principal crops, census, 1880, 1890, 1900, and 1910.¹

Census year.	Corn.		Hay and forage.		Wheat.		Oats.	
	Acreage.	Production.	Acreage.	Production.	Acreage.	Production.	Acreage.	Production.
		<i>Bushels.</i>		<i>Tons.</i>		<i>Bushels.</i>		<i>Bushels.</i>
1880.....	70,694	2,274,885	14,474	20,266	53,179	624,535	7,884	136,471
1890.....	139,963	5,357,063	69,989	111,729	46,483	1,066,035	26,329	803,923
1900.....	137,542	3,865,430	67,122	100,957	75,572	884,750	17,623	562,830
1910.....	144,627	3,193,843	73,051	116,142	30,196	393,070	25,472	668,564

¹ Figures apply to years preceding census years.

In 1879, corn, wheat, hay and forage, and oats were the principal crops, ranking in acreage in the order named. By 1889 the acreage devoted to each of these crops, except wheat, had been very largely increased. The acreage in corn had been practically doubled, that in hay and forage crops more than quadrupled, and that in oats more than trebled. The census of 1900 showed no great change in the acreage in corn or hay and forage, but the acreage in wheat was almost double that of 1889, while that in oats had been reduced by about 35 per cent. In 1909 the acreage in corn, hay and forage, and oats showed a slight increase, while that in wheat had been reduced by more than one-half from that of 10 years before. Kafir and milo had become important by 1909, the census reporting 14,152 acres in these two crops. The increase in hay and forage was probably due in large measure to the increased importance of alfalfa, the area in this legume in 1909 being reported as 22,727 acres and the production as 48,517 tons. The value of animals sold or slaughtered on farms in 1909 was \$2,757,571, slightly more than double that reported for 1899, and the value of dairy products sold reached \$262,356, having increased by almost 150 per cent during the preceding decade. Since the last census the acreages in alfalfa, kafir, and milo, and the value of live stock sold or slaughtered, have increased considerably, according to field observation and the statements of reliable farmers.

The principal products of Cowley County, namely, corn, hay and forage, wheat, oats, kafir, milo, and live stock, are produced to a considerable extent for sale, although a large part of the corn, hay and forage, and kafir is used on the farm as feed for work animals and other live stock. The principal varieties of corn grown are the Silver Mine, Boone County White, and Hildreth's Yellow Dent. Of wheat, the May Queen and Oregon Red are the principal soft varieties, and the Kharkof and Turkey Red are the most important hard varieties. The Black-hulled White is a commonly grown variety of kafir.

The principal hay crops are wild grasses, alfalfa, millet, clover, and timothy. The acreage devoted to alfalfa is probably increasing more rapidly than that of any other crop, but the acreage in kafir, milo, and feterita is increasing at a more rapid rate than that of corn and small grain. At first the growing of alfalfa was confined to the bottom-land soils, but this crop is now grown in the uplands upon a constantly increasing acreage, and there is apparently no reason why the growing of alfalfa, milo, kafir, and feterita could not be largely extended with profit on the better upland soils. Alfalfa may be expected to suffer more from drought on the upland soils than in the bottoms, but crops such as milo, kafir, and feterita may be expected to give satisfactory results in normal years.

The 1910 census reports 189,647 apple trees, 107,167 peach trees, 60,700 grapevines, 21,026 nut trees, 98 acres of blackberries, and 43 acres of strawberries in the county. Fruit growing is of little importance commercially, although a few farmers produce apples for shipment.

The live-stock industry consists mainly of fattening feeder cattle. Most of the animals are shipped in from Texas in the spring, but a few local ranchers have large herds of cows and raise a large part of their beef stock. The cattle are kept on pasturage until late in the fall, and are wintered on silage, grain, corn fodder, kafir fodder, alfalfa, and prairie hay. In some cases the cattle are sold in the early fall as "grass-fed" stock. Generally the cattle have no shelter during the winter other than that afforded by the timber along streams and by the deep gulches in the eastern part of the county.

There are no large commercial dairy farms, although several herds of Holstein and Jersey cows are maintained. Nearly every farm produces some cream for sale from a small herd of cows. The product goes largely to creameries in Arkansas City and Winfield and to the condensery at Mulvane. Nearly every farmer raises a few hogs, cattle, and horses. Some farmers specialize in hog raising, Duroc Jersey, Poland China, and Berkshire being the most popular breeds. Several small flocks of sheep are kept, but sheep raising is of little importance.

In the stream bottoms, in which practically all the land is under cultivation, general farming is carried on with comparatively little raising of live stock. The bottom-land soils are devoted largely to alfalfa, corn, and wheat. In the uplands, where perhaps the greater part of the land is not cultivated, the prevailing type of farming is hay production, with general farming and the raising and fattening of live stock as important adjuncts. The cattle subsist principally upon native grasses, but are fed for comparatively short periods in the winter.

The predominance, from place to place, of these three principal lines of agriculture—namely, general farming, the raising and fattening of live stock, and hay production—depends to a considerable degree upon the character of the soils and the topography. General farming in the uplands is to some extent restricted to the better soils, such as those of the Crawford and Summit series, and the pasturing of stock and hay production are carried on more extensively where the clay-hardpan subsoils and the rougher types of topography predominate. The rougher lands in the eastern part of the county are used very largely for the raising and fattening of beef cattle. The transportation facilities here and the ready access to large live-stock markets are favorable to the development of stock raising.

Good grazing is available throughout the county, even on slopes too steep or stony to be plowed, and conditions in general point to an increase in cattle and hog raising, particularly on the rougher uplands.

The Osage and Canadian soils are most extensively used for alfalfa, the farmers recognizing these types as being peculiarly adapted to this crop. Although used also for alfalfa, the other bottom-land soils are more extensively used for corn and wheat. These crops ordinarily give heavy yields, but wheat occasionally tends too much to the production of straw. In the upland the soils of the Summit, Crawford, Derby, and Gerald series are recognized as better for wheat and corn than those of the Oswego series, and the Summit, Crawford, and Derby soils as better suited to alfalfa than the Oswego and Gerald types. To some extent these natural crop adaptations are followed by the farmers in choosing fields for these staple crops. The sandy soils of both bottom land and upland are recognized as well suited to sweet potatoes and melons, and they are locally selected for such crops as these. The shallow phase of the Summit silty clay loam is considered better adapted to the raising of live stock than to any other agricultural use.

Almost all the farms are well equipped with modern farm machinery, including 2 to 5 horse turning plows, disk plows, spring-tooth and spike-tooth harrows, riding cultivators, mowing machines, manure spreaders, hay stackers, hay loaders, rakes, binders, corn binders, and gasoline engines. Several tractors are also in use in the county. Thrashing outfits are moved about the county to serve the farmers soon after harvest time. The work stock consists of medium to heavy draft horses. Very few mules are seen.

In growing wheat the ground is generally plowed early, to a depth of about 4 to 8 inches, the latter depth being reached about once in 3 years. The land is frequently disked once and harrowed twice. These operations usually put the seed bed in good condition. Most of the corn is listed, the land being plowed and planted at a single operation, without other preparation. Milo, feterita, and kafir are also generally put in with a lister, although part of the kafir and feterita is seeded with a drill. Subsequent cultivations, of which ordinarily there are 3 or 4, are shallow and are usually performed with 2-horse riding cultivators.

The best results with alfalfa are obtained when the crop is seeded in the spring on a well-prepared seed bed. A good stand of alfalfa on bottom-land soil has been known to last 30 years.

Not much attention has been given in the past to the rotation of crops, and even now rotations are followed only by a comparatively small number of farmers. Changing from a clean-cultivated

crop to a legume, such as alfalfa, is the essential feature of the best rotations. Corn, small grain, and kafir and related crops all do well on land where alfalfa has been grown. (See Pl. I, fig. 1.)

No commercial fertilizer is used by Cowley County farmers. Barnyard manure is applied to the land to some extent, and occasionally a crop of alfalfa is plowed under. Many farmers make little effort to utilize the animal manure produced, and it is in many cases entirely wasted.

Farm labor is rather scarce, and there is usually little demand for hired hands except during the busy seasons. Many farmers, however, hire farm laborers for the entire year, paying \$25 to \$35 a month, in addition to board. Day labor during the harvest season receives \$2 to \$2.50 a day and at other times \$1.50 or \$2 a day. Married farm hands are usually paid \$35 to \$50 a month, in addition to a house, a garden plot, a cow, and fuel.

The farms range widely in size, from those containing only a few acres, as in the vicinity of Arkansas City, where market gardening is carried on, to those comprising thousands of acres, as in the eastern part of the county, where stock raising is the most important industry. The average size of the farms is given by the 1910 census as 206.3 acres.

The census shows 58.7 per cent of the farms operated by owners, 40.4 per cent by tenants, and 0.9 per cent by managers. Wheat land usually rents for about \$3 an acre cash or one-third of the crop. Rental is in general on a share basis, the respective interests of owner and tenant in the crops produced depending upon what is furnished by each. Some farms, however, are rented for cash, the usual rate for general-farming land being about \$3 an acre. Pasture-land rental depends upon the number of cattle maintained; where there is an average of about 7 acres for each animal the rate is 75 cents an acre, while where only 4 or 5 acres are allowed per animal the rate is \$1 an acre. Where large tracts of land are rented for pasturage the usual rate is \$1 an acre.

Land values vary according to the location of the farm with respect to markets and transportation facilities, the topography, the soil, and the improvements. Throughout the greater part of the county farm land is held at \$50 to \$125 an acre. In the rougher country in the eastern part, land is held at \$20 to \$60 an acre.

The farmhouses are as a rule large and well built. They are generally constructed of wood, but there are many stone houses, particularly in the eastern part of the county. Many of the barns also are built of stone. They are generally large, with considerable storage room for hay and grain.

SOILS.

According to Haworth,¹ the rocks of Cowley County are all sedimentaries. From the west county line eastward to a line that may be roughly generalized as the course of Grouse Creek, the rocks are largely limestones and shaly limestones of Permian age. East of this stream the rocks belong mainly to the Pennsylvanian division of the Carboniferous. There are, however, in the eastern part of the county a few flat-topped hills, reaching about 1,500 feet in elevation, which are capped with a cherty limestone of Permian age. These hills stand high above the surrounding country. The rocks belonging to the Carboniferous are largely shaly limestones, cherty limestones, and chert, with some sandstone, the latter occurring only in small developments in the southeastern part of the county.

The upland soils are of residual origin, derived very largely, in so far as can be determined, from limestone and from interbedded limestone and cherty limestone. In the eastern part of the county, in the Flint Hills section, chert is abundant, but in the central and western parts it is much less in evidence. The limestone is moderately thick bedded and ranges from massive to shaly. It is possible that material from sandstone and shale, which have in general disappeared through weathering, is present to a greater or less extent in some of the upland soils. What little shale and sandstone is present occurs only at the lower levels or below the dominant limestone and shaly limestone, the parent rocks. In the eastern part of the county, along the slopes capped with limestone, there are several narrow strips of pinkish-red or chocolate-red, clayey soils, derived from pinkish-red shales and to some extent from sandstone. These reddish soils represent the Vernon series, and those having a dark surface soil and a chocolate-brown subsoil the Kirkland series. These two series are extensively developed in the Red Beds region of Oklahoma and Texas and in more westerly counties in Kansas. In Cowley County, however, they occur in patches too small to show on a map of the scale used.

While the soil material in the uplands, representing the accumulated residuum apparently formed largely through the decay of limestone, is predominantly calcareous, it is normally much less calcareous than the limestone. This fact, however, is not incompatible with the theory of derivation from this rock, since the decomposition of the rock would be accomplished largely by the removal of calcium carbonate (CaCO_3) in solution. Texturally, the soils are high in silt

¹ Vol. IX, Reports of the University Geological Survey of Kansas, on Oil and Gas, by Haworth.

in the surface layer and contain relatively large quantities of clay in the subsoil; structurally, the surface soils generally are mellow and friable, and the subsoils either very stiff and plastic or moderately friable. The cause of the marked difference in structure of the various subsoils is not well understood, but it is significant that the tougher clays are largely confined to the level or nearly level areas and the moderately friable clays to the undulating and gently rolling areas. The most friable clays of these residual soils are less friable than those of the dominant limestone soils in the East, such as the Hagerstown and Decatur series of the Appalachian Valley regions.

The chief relationship between topography and soil characteristics exists in the development of the thin, stony soils on the slopes flanking drainage ways; in the occurrence of those types with tough, clay subsoils on level and faintly undulating areas, and of those with moderately friable subsoils, principally over the undulating and rolling areas; and in the restriction of types with decidedly friable subsoils, those of the Derby series, to a comparatively narrow strip of undulating and level country bordering the Arkansas River bottoms.

The upland soils of Cowley County are classed in the Summit, Oswego, Gerald, Crawford, and Derby series. The Summit, Oswego, and Gerald soils are somewhat similar, but the subsoil clay of the Summit series does not assume the very tough structure characterizing the "hardpan" or clay-pan features of the Oswego and Gerald subsoils. The Crawford types have reddish subsoils. friable in structure, at least in the upper part.

The Summit series, representing the most extensive group of soils in the county, is characterized by very dark brown to black, friable surface soils overlying yellowish subsoils, usually consisting of clay which is sticky when wet but slightly friable when moderately moist. Frequently the yellow material is not reached except in the lower part of the 3-foot section, and on this account it is not everywhere easy to draw sharp boundaries between the Summit soils and the Oswego and darker Gerald soils, especially in the southwestern part of the county. The typical yellowish clay usually has a greenish cast. Where the underlying limestone lies at shallow depths the subsoil frequently contains soft, whitish, highly calcareous material, and is more friable than is characteristic. The subsoil is generally calcareous. The underlying rocks, seen in exposures, consist of limestone, shaly limestone, and beds of cherty limestone. The topography of the Summit soils is undulating to rolling, with many steep slopes and occasional level areas. It is on the average not nearly so smooth as the topography of the Gerald series. The drainage is well established. In Cowley County the Summit stony loam, silt loam, and silty clay loam, the latter with a shallow phase, are mapped. In

areas of the shallow phase some patches of Brackett¹ soil are included.

The Oswego soils are characterized by the black color of the surface material and by the tough structure and dark-brown to black color of the heavy clay subsoils. Usually this tough clay, which has the nature of hardpan, begins abruptly at a depth not greater than 10 inches. The rocks from which these soils are derived could not be determined in the soil-survey field work, as there were no exposures or ledges near the surface. These soils are closely associated in occurrence with those of the Gerald and Summit series, indicating that they are, to some extent at least, residual from limestone. Typically, the surface is approximately level, although a few areas are gently sloping. The drainage is imperfect in many of the more nearly level areas, but all variations of the Oswego silt loam, the only member of the series encountered, are cultivated to some extent. This series represents the dark equivalent of the Gerald.

The Gerald soils characteristically have brown, friable surface soils and chocolate-brown or dark-brown to dark yellowish brown, tough clay subsoils having the nature of hardpan. Frequently the upper subsoil is reddish and somewhat similar to that of the Crawford series, but it passes beneath into tough clay of a more brownish or dark yellowish brown color mottled with chocolate brown or reddish brown. The material is residual from limestone, at least in part. Shale may have entered into the composition of the soil, but no trace of this rock remains. These soils mostly occupy undulating to gently rolling or gently sloping areas; occasionally the surface is level. The drainage is not everywhere well established, but is better as a rule than that of the associated Oswego soils. The silt loam and silty clay loam, the two Gerald soils encountered in this county, are extensively developed.

The Crawford soils are friable and reddish brown to brown or even dark brown in the surface part. In the subsoil they consist of red to reddish-brown friable clay, which becomes stiffer in the lower depths and frequently shows some yellowish and brownish mottling. This material is residual from limestone, and in many places the limestone is reached within the 3-foot section. These soils are found on slopes, ridges, knolls, and nearly level and undulating areas. The drainage is everywhere good. The Crawford loam and silt loam, the latter with a shallow phase, are mapped in Cowley County.

Immediately adjacent to the lowlands of the Arkansas River there is developed soil material of an entirely different class, at least as measured by friability. This material is friable in both surface soil

¹ The Brackett soils consist of grayish to whitish, highly calcareous, chalky material.



FIG. 1.—ALFALFA IN THE FOREGROUND; CORN SECOND YEAR AFTER ALFALFA IN MIDDLE DISTANCE.

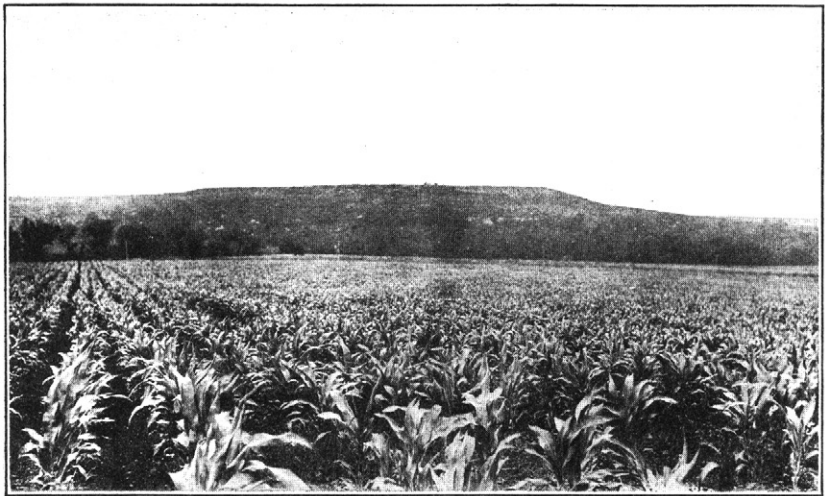


FIG. 2.—KAFIR ON SUMMIT SILT LOAM, 1½ MILES EAST OF CAMBRIDGE.

and subsoil, that nearest the river being decidedly friable throughout the 3-foot section, although somewhat more compact in the subsoil. Farther from the river the material becomes heavier in texture, especially in the subsoil and more compact. It is difficult to determine, in places, sharp lines of separation between this material and definite residual material such as that of the Crawford and Summit series. Friable soils believed to have originated in considerable part, at least, from wind-blown material transported from the bottom-land soils along the Arkansas River containing considerable sand, are classed in the Derby series.

The Derby soils are characterized by the brown color and friable structure of the surface material and by the reddish-brown to dull-red or reddish-yellow color and friable structure of the subsoil. The subsoil differs from that of the Crawford series principally in its more friable nature and somewhat lighter texture. The Derby soils occupy level to undulating areas and gentle slopes along and near the Arkansas River bottoms; they have well-established drainage. As mapped they include, near the river, areas in which the material corresponds very closely to the characteristics of the loessial Knox series. In Cowley County the Derby fine sand, fine sandy loam, loam, and silt loam types are mapped.

The soil material of the stream-bottom lands consists of alluvium—that is, sediments laid down over the stream-flood plains from overflow waters. Near the headwaters of the smaller streams and in shallow drainage-way depressions much of the material is colluvial, having been washed from the near-by slopes, but there is little difference, if any, between the soil material here and the true alluvium along the larger streams. In the first bottoms of the streams rising within this county and adjoining counties, where the upland soils from which the material has been washed include those of such series as the Summit, Gerald, Oswego, and Crawford, the alluvium is pre-vaillingly dark colored and becomes heavier in the subsoil. This material is classed in the Osage series. Along the Arkansas River, however, where the overflow waters carry sediment from distant regions, including the Rocky Mountain region, where the soils are unlike those encountered within the county, the first-bottom soil material is pre-vaillingly lighter colored and becomes more friable with depth and the lower subsoil is more sandy and friable than the upper subsoil. The soils here are classed in the Arkansas series. The Arkansas bottom soils are to an important extent sandy, while in the other stream bottoms sand is conspicuously lacking in the soils.

The Osage soils are black or nearly black in the surface part, grading beneath into dark-brown or black, rather compact material, which frequently is lighter brown in the lower depths. These soils

are subject to overflows, but between periods of overflow the drainage is good. The Osage silt loam, silty clay loam, and clay are identified in Cowley County.

The surface soils of the Arkansas series are characteristically brown in the lighter textured types and dark brown to black in the heavier types, overlying subsoils of yellowish-brown to brown color and of compact structure, which pass in the lower part of the 3-foot section into more friable sandy material. These soils are subject to occasional overflows from the Arkansas River, but between inundations the drainage is good. The Arkansas fine sand, fine sandy loam, very fine sandy loam, loam, silt loam, and clay are developed in Cowley County.

Along the outer margin of the bottoms there are in many places strips of alluvium occupying terrace situations, where the surface stands above the level of normal overflows. On the lower terraces of the larger streams of the county the material is different from that of the overflowed bottoms and gives rise to types with brown, friable surface soils and subsoils. It is classed in the Canadian series. A grayish soil occurring on low terraces along the Arkansas River, with a clay, hardpanlike stratum, a distinguishing feature, is classed in the Neosho series.

The Canadian series includes surface soils of brown color and friable structure, with light-brown to yellowish-brown, friable subsoils. The members of this series occur on stream terraces having good drainage. The material represents wash from the soils of the Great Plains region. The Canadian silt loam is the only member of the series encountered in Cowley County.

The Neosho soils, as mapped in this county, are dark gray in the immediate surface layer, overlying ashy-gray, powdery material in the subsurface stratum. This is underlain abruptly by a dark-brown to black clay of a hardpan nature. The silt loam, the only type of the Neosho series mapped in Cowley County, is not so light colored as are the typical Neosho soils mapped in other parts of the Great Plains Region, but its characteristics approach those of the series sufficiently to be mapped with it. It occurs on level stream-terrace areas, the drainage of which is imperfect. The material is old alluvium, apparently corresponding in origin with that of the Osage series.

In the following table are given chemical analyses of some of the soils of Cowley County, made in the laboratories of Southwestern College, at Winfield, under the direction of Prof. R. B. Dunlevy, professor of chemistry and geology. The results were obtained by the fusion method, carbon being determined by the Parr calorimetric method. The analyses were worked in duplicate and no results were accepted that did not show concordance.

Chemical analyses of certain soils.

Soil.	Location.	Sample zone depth in inches.	Potas- sium.	Lime.	Phos- phorus.
			<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>
Summit silty clay loam.....	Sec. 2, T. 30, R. 4...	1 to 7	0.1973	0.0371	0.3341
Crawford silt loam.....	Sec. 6, T. 33, R. 4...	1 to 7	.2738	.1429	.0584
Do.....	do.....	7 to 20	.2738	.6432
Do.....	Sec. 9, T. 35, R. 4...	1 to 7	.1586	.2144	.0777
Do.....	do.....	7 to 20	.1196	.536	.0829
Osage silty clay loam.....	Sec. 25, T. 31, R. 4...	1 to 7	.3418	.122
Do.....	do.....	7 to 20	.3455	.4645	.1902
Arkansas very fine sandy loam.....	Sec. 18, T. 32, R. 3...	1 to 7	.2118	.2072	.399
Do.....	do.....	7 to 20	.2174	.8223	.0343
Canadian silt loam.....	Sec. 10, T. 23, R. 4...	1 to 7	.2078	.4109	.1961
Do.....	do.....	7 to 20	.2825	.2823	.1754
Do.....	do.....	20 to 40	.2779	.6416	.0698
Neosho silt loam.....	Sec. 12, T. 33, R. 3...	1 to 7	.3262	.3716	.0651
Do.....	do.....	7 to 20	.3237	.3395	.2613
Do.....	Sec. 17, T. 32, R. 4...	1 to 7	.2239	.3359	.1718
Do.....	do.....	7 to 20	.1063	.2949	.1710

In the following pages the various soil types are described in detail and their relation to agriculture briefly discussed, while the distribution of the various soils over the county is shown on the map accompanying this report. The actual and relative extent of the several types are given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Summit silty clay loam.....	125,568	29.5	Derby loam.....	9,152	1.3
Shallow phase.....	88,832		Arkansas fine sand.....	9,024	1.2
Summit silt loam.....	95,360	13.2	Derby fine sandy loam.....	5,952	.8
Crawford silt loam.....	74,624	11.0	Arkansas very fine sandy loam.....	5,120	.7
Shallow phase.....	5,184		Arkansas loam.....	3,456	.5
Gerald silt loam.....	78,464	10.8	Arkansas silt loam.....	3,392	.5
Summit stony loam.....	51,328	7.1	Arkansas fine sandy loam.....	2,624	.4
Osage silt loam.....	43,520	6.0	Crawford loam.....	2,304	.3
Derby silt loam.....	23,232	3.2	Arkansas clay.....	2,176	.3
Osage silty clay loam.....	23,040	3.2	Osage clay.....	1,984	.3
Gerald silty clay loam.....	21,312	2.9	Derby fine sand.....	1,024	.1
Oswego silt loam.....	19,840	2.7			
Neosho silt loam.....	17,344	2.4	Total.....	725,120
Canadian silt loam.....	11,264	1.6			

SUMMIT STONY LOAM.

The Summit stony loam consists of a brownish to black silt loam or silty clay loam, underlain at a depth of about 3 to 5 inches by a

dark-brown to black clay. This passes quickly into brownish or yellowish, friable material. In many places soft, whitish, incompletely decomposed limestone is conspicuous in the subsoil. In patches the soil is whitish and shallow, while elsewhere it is of considerable depth, really representing patches of shallow Summit silty clay loam. Bedrock is ordinarily reached within about 3 to 10 inches of the surface, and outcrops of soft, shaly and heavy, massive limestone are quite common. Small fragments of chert and limestone and large blocks of limestone are scattered over the surface and throughout the soil profile.

This type occurs in scattered areas over the entire county, principally in narrow strips on ridges and steep slopes along stream valleys and as escarpments between the high uplands and stream valleys. The surface is rough and broken. The slopes range from rather steep to precipitous along the streams and on the sides of the mesa-like elevations. The topography is roughest in the Flint Hills section of the county, where the type is most extensively developed.

The Summit stony loam is little used for cultivation, but it is an important soil for the grazing of live stock. It is used entirely as pasture land or for the growing of prairie hay.

SUMMIT SILT LOAM.

The typical Summit silt loam consists of a dark-brown or nearly black, fairly mellow silt loam, underlain at a depth of about 8 to 10 inches by a brown to dark-brown silty clay loam. This passes at about 12 to 14 inches into a dark-brown, moderately friable clay that becomes more compact with increase in depth, grading into a yellowish-brown clay, which frequently shows a greenish shade in the lower part. Whitish, partly decomposed limestone is commonly reached within 3 or 4 feet of the surface, and where this material is present the lower subsoil is generally a greenish-yellow, sticky clay. Where there is much of this whitish material the subsoil is more friable than elsewhere. In the more nearly level areas the yellowish clay lies deeper, and in some of the lower lying level tracts the deep subsoil has a rather dark grayish color. In areas at higher situations or on drainage divides, as east of Dexter and on the divide west of the Otter Creek Valley, the soil is somewhat lighter in color than typical, and the subsoil is heavier and tougher, with some faint reddish brown mottling in the deep subsoil. In places some reddish mottling is also encountered in the subsoil, as in the area about 1 mile east of Dexter.

When dry the subsoil is compact, but it never becomes so compact or tough as the subsoil of the typical Oswego and Gerald soils, and the clay, at least in the typical development, is slightly friable. In places, however, the Summit silt loam grades into the Oswego

and Gerald soils in such a way that sharp boundaries are difficult to draw. This is noticeably the case in the southwestern part of the county, where the yellowish color frequently is not reached, except in the deepest subsoil. It is probable that a few patches of Gerald silt loam and Summit silty clay loam are included with the type as mapped. In the northwest and southwest quarters of sec. 11, T. 34, R. 3, and about one-half mile west of Blue School, small areas of Summit loam are included with the silt loam, and in the northwest quarter of sec. 32, T. 31, R. 3, a small development of Summit very fine sandy loam is included.

The Summit silt loam occurs throughout the uplands of the county. Extensive areas are found north and northeast of Burden, to the east and northeast of Dexter, and in the southwest corner of the county.

The greater part of the type is undulating to gently rolling, but there are numerous level or nearly level areas, as in the vicinity of Eaton and south of Cambridge. The type in general occurs over higher positions than does the Summit silty clay loam, but there are many small areas in relatively low positions, as on slopes and in rather flat strips along drainage ways. Nearly all the type is topographically well suited to tillage, permitting the use of all kinds of modern farm machinery, and there is only a relatively small area where the slopes are steep enough to be eroded seriously under cultivation.

In general the type has good surface and internal drainage. Some of the more level tracts, however, as in the vicinity of Eaton, have imperfect surface drainage, with the result that the surface soil in places has an ashy cast when dry, while the subsoil tends toward bluish-gray and pale-yellow colors.

The Summit silt loam is an extensive soil, and it holds a very important place in the agriculture of the county. Probably 75 per cent of the land is used for cultivated crops, the remainder being in native hay lots and pasture. Wheat is the most important crop grown, constituting the principal income product. Kafir, milo, feterita, corn, and alfalfa are grown to a considerable extent—much of the hay, feed, and forage being fed to the work stock and to cattle and hogs, of which a few are kept on most farms to supply home needs. Some small apple orchards to supply fruit for home use are found. Stock raising is of little importance on this type, except in the more broken country in the eastern part of the county, where some beef cattle and hogs are raised for market. Many farmers on this type sell some cream.

Wheat on the Summit silt loam yields 20 to 30 bushels per acre¹ in good years. Yields of more than 30 bushels are sometimes ob-

¹Information in this report as to yields of crops is based on statements of farmers and on field observations.

tained, and in unfavorable seasons they may be considerably less than 20 bushels. Corn yields ordinarily 35 to 50 bushels per acre, and alfalfa gives four cuttings, which total approximately 4 tons per acre. The nonsaccharine sorghums, including kafir and feterita, give good yields. Plate I, figure 2, shows a field of kafir on this soil.

In growing wheat the land is prepared for the next crop soon after thrashing is completed. Plowing is ordinarily about 6 inches deep and is done usually with turning plows drawn by 2 to 5 horses. A few tractors are in use for plowing. Spike-tooth and disk harrows are used to reduce the soil to a fine tilth. Corn is planted with the lister, the seed being dropped and covered by an attachment on the plow that makes the water furrow. Alfalfa is seeded in either the spring or fall on thoroughly prepared land. Cultivation of the tilled crops is performed at frequent intervals, with shallow-running, riding cultivators. The rotation of crops is not practiced generally on this type, and no commercial fertilizers are used. Some farmers apply barnyard manure, but many allow this material to go to waste.

Land of this type is at present valued at about \$50 to \$100 an acre, the price depending on the topography, location, and improvements.

This soil is naturally so productive that it has not been necessary to employ the careful methods of culture followed in older farming regions and those of less productive soils. It would be well for the farmers to practice better methods of farming. Experience shows that yields can be increased by manuring the land and by rotating crops, and especially by growing at intervals a legume, such as alfalfa.

The lister method of planting corn, which places the seed near the more or less compacted plow sole in which the root system begins to develop, is commonly used. The soil is not difficult to plow, and thorough preliminary breaking and harrowing of the land before planting the seed, with better cultivation, would undoubtedly give increased yields. Some of the imperfectly drained areas, including that about Eaton, would be benefited by tiling.

SUMMIT SILTY CLAY LOAM.

The Summit silty clay loam differs from the Summit silt loam mainly in its heavier texture. The typical soil consists of a black silt loam, underlain at about 1 to 4 inches by a black, friable silty clay loam. This grades at 5 to 8 inches into a black, crumbly clay which becomes more compact and browner in color below, the lower subsoil being usually a yellowish-brown clay. In the areas of shallower soil, including the higher flats and more gentle slopes, the subsoil is a yellow or greenish-yellow clay and contains whitish calcareous

material. Here the surface material is more friable than on most of the slopes, where the subsoil is darker brown in color or is less yellow and more plastic. Ordinary plowing, however, converts the surface soil here into a silty clay loam by mixing clay from the subsurface stratum with the surface material. Limestone immediately underlies this type, and outcrops are frequent throughout its occurrence. Stony areas containing limestone and chert fragments are also common. As far as practicable such areas have been separated as the Summit stony loam.

The Summit silt loam and the shallow phase of the Summit silty clay loam are closely associated with this type and small areas of these soils are included with the silty clay loam. Several areas of Summit clay were also included on account of their small extent. They occur about $2\frac{1}{2}$ miles northwest of Cambridge, 2 miles northwest of Hooser, and south of Valley Center School.

The Summit silty clay loam occurs in every part of the county, but it is best developed in the eastern part. It occupies large areas in the Flint Hills region around Grand Summit, at the headwaters and west of Otter Creek, north of Dexter, east of Winfield, and in the southeastern part of the county.

This type occurs in high, undulating situations on the slopes toward streams, in front of limestone escarpments, and along drainage ways. Its topography ranges from undulating to rolling and hilly. Occasional level areas are encountered on drainage divides, but the typical position of this soil is along the breaks to water courses. The drainage is thorough and on the steeper slopes the run-off is so rapid that some washing of the soil takes place.

The Summit silty clay loam is the most extensive soil in the county. Wheat, corn, kafir, feterita, and alfalfa are important crops. Kafir and feterita are replacing corn to a large extent, because of their drought-resistant qualities. The wheat is usually sold as a money crop. The greater part of the production of the other crops is used on the farm to feed work stock, hogs, and cows, and to winter steers. A large acreage of this type is used for the production of prairie hay, which is baled and sold.

Raising live stock is an important interest, especially in the eastern part of the county, where the type is used almost entirely for grazing cattle. Water is plentiful, and the land supports an abundant growth of prairie grass, which furnishes excellent grazing during the spring, summer, and early fall months. The steers are put on pasturage early in the spring, and are sometimes sold in the fall as grass-fattened beef. Those not marketed in the fall are fed through the winter on kafir fodder, corn silage, and alfalfa and prairie hay. Dairying is unimportant, but most of the farmers keep

a few cows, which supply a small surplus of cream for sale. Many farmers raise hogs for shipment.

The yields of crops on this type do not differ greatly from those obtained on the Summit silt loam. Wheat yields 15 to 30 bushels an acre and corn 25 to 40 bushels. Alfalfa gives four cuttings. The average yield of prairie hay is about three-fourths ton per acre.

It is somewhat more difficult to handle land of the Summit silty clay loam than of the associated silt loam type. Plowing requires heavier implements and work stock. When the land is broken under unfavorable moisture conditions it clods to some extent, but if plowed when the moisture content is right it works up into a desirable tilth.

In the western part of the county land of the typical Summit silty clay loam is valued only slightly lower than the Summit silt loam, but the rougher areas, such as those in the Flint Hills region, used largely as pasture land, sell for \$20 to \$65 an acre.

In growing alfalfa too little care is taken in preparing the seed bed. Weeds are the cause of many of the poor stands obtained.

Summit silty clay loam, shallow phase.—The shallow phase of the Summit silty clay loam consists of a black silt loam or silty clay loam which passes abruptly into silty clay loam, overlying, at a depth of about 5 to 8 inches, a black, somewhat crumbly clay. This passes into a yellowish-brown to dark-brown clay, which is compact and only slightly friable when dry and plastic when wet. Bed limestone or a mass of chert fragments is reached at any depth between about 8 and 24 inches. On perhaps 50 per cent or more of the phase the limestone or chert lies very near the surface, directly below the black-clay surface soil or a thin subsurface layer of whitish, highly calcareous material, the brownish or yellowish subsoil proper being absent. Rock outcrops are quite common in areas of this phase.

Large limestone fragments and some of chert are scattered over the surface. Areas of sufficient extent in which these occur in abundance are separated and mapped as the Summit stony loam. A few small areas of soil resembling the Brackett silty clay loam and stony silty clay loam are mapped with the phase.

The Summit silty clay loam, shallow phase, is very extensive, occurring in every part of the county. It is particularly extensive in the eastern part, being one of the predominating soils in the Flint Hills region. It occupies level and undulating areas upon the divides and gentle slopes and the mesalike tops of hills. It also commonly occurs around the heads of streams and along drainage ways. Its topography in places, especially in the "breaks" along stream courses, is steep to precipitous. Surface drainage is good to excessive, but the underlying limestone tends to prevent the downward movement of water.

On the whole this is an important soil, being largely used for pasturing stock on the native prairie grasses. The live-stock industry is well developed in the eastern part of the county on this phase. A comparatively large acreage is left in grass to be cut for hay, which is baled and sold. The phase is largely unsuitable for cultivation, because of the nearness of the limestone to the surface, which makes the soil too droughty to be used with much success for such crops as corn, wheat, kafir, and alfalfa. Land of this phase sells for about \$20 to \$45 an acre.

It would be advisable to protect the grass to some extent during hot, dry seasons by allowing a larger acreage to each steer.

OSWEGO SILT LOAM.

The typical Oswego silt loam consists of a black silt loam, underlain at a depth of 6 to 10 inches by a clay hardpan consisting of black, tough, heavy clay. This material shows little change within the 3-foot section, except that in the lower part it is frequently lighter colored, being very dark drab to very dark brown or nearly black, with some yellowish-brown and dark-colored concretionary material. When dry the subsurface material in places has a dark ashy gray color immediately over the clay. This type is the black equivalent of the Gerald silt loam. It is locally known as "hardpan" land.

Those areas northeast and southeast of Otto include many small patches of Oswego silty clay loam, as do also those east and south of Maple City. The large areas of this type at Grand Summit and just north of Hooser contain much silty clay loam soil in areas too small to map. On the Chautauqua County line $1\frac{1}{2}$ miles north of Rock Creek an area of Oswego silty clay loam has been included.

The Oswego silt loam occurs in areas rather regularly scattered over the county. The largest area is that about 4 miles southwest of Arkansas City. Other large areas occur one-fourth mile and 7 miles north of Hooser, 2 miles southeast of Dexter, one-fourth mile west of Grand Summit, about 6 miles northwest of Winfield, about 6 miles west of Atlanta, west and north of Udall, and northeast and southeast of Otto.

The greater part of the type is characteristically level, but there are some areas, as in the vicinity of Otto, of gently undulating surface. As a whole the Oswego silt loam is poorly drained. Its nearly flat topography does not favor rapid run-off, and the dense subsoil retards the downward movement of water.

This type is inextensive in comparison with the other important upland soils. Practically all of it, however, is in cultivation. It is used largely for wheat, which is the principal cash crop (see

Pl. II, fig. 1). The remaining cultivated areas are in corn, kafir and related crops, and prairie hay, much of which is used as feed for the work stock and other domestic animals. Cattle and hogs are raised on most of the farms, but raising live stock is of little importance on this type of soil.

Wheat on the Oswego silt loam yields about 15 to 25 bushels an acre, the yields varying with the season. The average yield of corn is rather low, about 25 bushels an acre. Kafir produces about 30 bushels an acre. Some alfalfa is grown, but as a rule the stands are not good.

This soil is rather difficult to handle, except under the proper moisture conditions. If it is stirred while wet it bakes and clods upon drying. In hot, dry seasons the soil cracks badly unless cultivated frequently, often injuring growing crops.

Land of the Oswego silt loam is held at about \$40 to \$75 an acre.

This soil is not naturally so productive as the Summit silt loam, owing probably in some measure to its tough, impervious subsoil. It could be made more productive by tile drainage, as experience has demonstrated that this not only removes the excess surface water but aerates the subsoil and makes it looser and more friable. Yields apparently could be increased also by deeper plowing, and it might be advisable to plow under vegetable matter occasionally, even though the soil is relatively high in that constituent in its present condition. Sweet clover is being tried by some farmers on this soil. This plant has a long taproot and this would tend to loosen the compact subsoil.

GERALD SILT LOAM.

The typical Gerald silt loam consists of a brown silt loam underlain at an average depth of about 8 inches by chocolate-brown or dark-brown, tough, heavy clay which, with increase in depth, changes to a little lighter shade, faintly mottled with darker shades of brown. The tough subsoil is locally called "hardpan," but it is essentially a clay which, though showing no cementation, becomes extremely tough and dry. In many spots where this clay is exposed at the surface the soil has a whitish appearance and is believed to be alkaline.

There is a variation of this type which is somewhat similar to the Crawford series in its upper subsoil, the material here being slightly friable and having a reddish hue. The subsoil, however, becomes very tough below and the color changes to brown or mottled yellowish and reddish brown. There are included areas where the soil approaches closely the characteristics of the Summit series, but the surface material is brown and the lower subsoil is very tough and not so yellow as that of the Summit types. Several small areas of Gerald

loam also are mapped with the silt loam. These are situated 2 miles north, one-half mile north, and one-fourth mile east of Atlanta, and at Geuda Springs, one-fourth mile north of the Kansas Southwestern Railway, on the Sumner County line. Small, intricately associated bodies of Gerald silty clay loam and Crawford silt loam also are included with this type. In the southeastern part of the county several areas of material which would be classed in the Bates series if of sufficient extent are also included.

The Gerald silt loam is encountered in every part of Cowley County, but it is inextensive in the eastern part. It is well developed in the vicinity of Atlanta, Rock, Udall, Winfield, Arkansas City, and Maple City. The type occupies undulating and level areas. It lies a little higher than the Oswego silt loam and is characterized by topography less smooth than that of the latter type. It is, however, more nearly level than the associated Summit soils. Its topography is not everywhere favorable to good surface drainage, and its dense subsoil tends to prevent thorough internal drainage. As a whole the type is only fairly well drained.

This type is very important in the agriculture of the county. A large part of it is in cultivation, the remainder being used as prairie-hay and pasture land. The leading crops are wheat, corn, oats, kafir, feterita, prairie hay, and alfalfa. Wheat is the principal money crop. A large part of the hay, corn, and kafir produced is used to feed work stock on the farm. A small proportion is sold and the remainder is used to feed hogs and dairy cows or to maintain beef cattle through the winter. The principal live-stock interests are cattle raising and pork production. Small dairy herds are kept on many of the farms. These subsist on pasturage the greater part of the year. Cream is sold at local markets. The system of farming prevailing over the type as a whole is rather uniform and the crops grown are of about equal importance. Difficulty has been encountered in establishing stands of alfalfa on this soil. Some failures have been due to unfavorably wet seasons and others to hot, dry weather, which causes the soil to crack badly. Sweet clover is being tried on this soil and indications are that it will prove a satisfactory crop.

Wheat on the Gerald silt loam yields 10 to 30 bushels an acre, the average being about 18 bushels, and corn yields 20 to 40 bushels. Oats do fairly well with sufficient rainfall. Kafir and feterita give satisfactory yields of forage and grain. Prairie hay yields one-half to 1 ton per acre.

Plowing on this type is usually shallow, because of its hard and dry condition in late summer. It is handled in much the same manner as the Oswego silt loam. No commercial fertilizers are used,

but barnyard manure has proved to be beneficial and is used to some extent.

Land of this type sells for about \$25 to \$75 an acre, the price depending upon the location, improvements, and the character of the surface.

Crop yields on this soil could be improved by deeper plowing and by turning under green vegetation and stable manure. In seeding alfalfa it would be advisable to take greater care in preparing the seed bed.

GERALD SILTY CLAY LOAM.

The Gerald silty clay loam consists of a brown to dark-brown silt loam, underlain at a depth of 2 to 5 inches by brown silty clay loam. This passes abruptly at an average depth of about 8 inches into a brown to yellowish-brown, stiff, heavy clay, having somewhat the character of hardpan, which it is locally called.

This type is most extensively developed south of Tisdale and in the vicinity of New Salem. The topography in many places is more undulating than that of the Summit silt loam. The drainage is imperfectly established in the areas of level surface.

The type is unimportant, because of its small extent. It is closely associated with the Gerald silt loam and the Summit silt loam and silty clay loam, and is used largely for the same crops. Yields are about the same as on the Gerald silt loam. The areas in the southeastern part of the county are used for the pasturing of beef cattle.

The Gerald silty clay loam has a narrower range of moisture conditions under which it can safely be plowed than has the silt loam type, and it is likely to clod and bake badly if plowed too wet.

The land is held at the same prices as the silt loam type.

The methods of soil improvement that are beneficial on the Gerald silt loam can be applied to the Gerald silty clay loam.

CRAWFORD LOAM.

The Crawford loam consists of a reddish-brown, mellow loam to a depth of about 8 inches, below which a lighter reddish brown loam is encountered. This passes at a depth of about 12 to 14 inches into dull-red, friable clay, which becomes deeper red in color and more compact below. At Martha Washington School and at several places to the east of that locality the surface soil is brown to chocolate brown in color and the lower subsoil is faintly mottled with yellowish brown. It is immediately underlain by limestone, the depth to which varies from a few inches to several feet. The subsoil effervesces slightly in hydrochloric acid.

The largest areas of this type occur at Mount Vernon Church, Martha Washington School, and South Bend School. Smaller areas

are encountered in different parts of the county. The type occupies gentle slopes and low knolls, the surface resembling that of the Crawford silt loam, with which this type is closely associated. The drainage is good.

While the Crawford loam is of only small extent, it is an important soil agriculturally, because of its productiveness and the fact that all its area can be cultivated. Corn, wheat, kafir, and hay are grown, the yields ranging as follows: Wheat, 15 to 35 bushels; corn, 35 to 50 bushels; oats, 25 to 40 bushels; and wild hay, about three-fourths ton per acre. Kafir yields well. The soil works up easily into a good tilth.

This land is held at about the same price as the Crawford silt loam.

CRAWFORD SILT LOAM.

The surface soil of the typical Crawford silt loam is a reddish-brown to chocolate-brown, mellow silt loam, underlain at a depth of about 8 inches by a reddish-brown, friable clay, which grades below into dull-red and then into brighter red, rather compact, though moderately friable, clay. Most of this type, however, as mapped is not typical, consisting of a brown to dark-brown silt loam, grading at a depth of about 5 inches into light-brown silt loam, this in turn passing at about 10 to 12 inches into a yellowish-brown or reddish-brown, crumbly clay that grades below into stiff red clay showing faint yellow and reddish-yellow mottlings in the lower part. Fragments of limestone are not uncommon in both surface soil and subsoil, and the material is calcareous. This type is known locally as "red land."

As mapped there are included with the Crawford silt loam some small areas of Crawford silty clay loam, consisting of chocolate-brown silty clay loam, underlain at 5 to 10 inches by a light-brown or dark yellowish brown silty clay loam which quickly passes into reddish-brown clay of a moderately friable structure. These included areas of silty clay loam occur 5 to 6 miles northeast, 3 to 7 miles east, and 4 to 5 miles south of Winfield, and elsewhere scattered over the entire county. Some small areas of Gerald silt loam and silty clay loam and of Crawford silt loam, shallow phase, also are included in this type. A number of small gravelly areas are shown on the soil map with gravel symbol.

The Crawford silt loam is quite extensive in the western part of the county. The largest areas are encountered paralleling the west bank of Walnut River in a discontinuous strip, averaging about 2 miles in width. Other large areas are developed in the vicinity of Rock, about 5 miles northeast of Winfield, and between the Walnut and Arkansas Rivers about 4 miles northeast of Arkansas City.

In general the type occupies slopes and ridges. It has, however, a wide range in topography, and in some of the more broken sections of the county it occupies gently rolling to rolling country. The type is well drained, but the subsoil retains moisture, so that crops do not suffer in seasons of ordinary rainfall. Crops are, however, injured by hot, dry weather, especially in those places where the underlying limestone lies close to the surface.

The Crawford silt loam is an important soil in the agriculture of the county. The most important crops are corn, wheat, kafir, feterita, oats, prairie hay, and alfalfa. Wheat probably occupies the largest acreage, followed by corn, kafir, and alfalfa. Wheat is grown as a money crop, but only a small proportion of the other crops is sold, the greater part being used to feed work stock, hogs, and cattle. The main live-stock industries are the raising of hogs and the feeding of steers for market. A few cows are kept on most farms, and some cream is sold. The Crawford silt loam is one of the best upland soils for alfalfa, which has proved to be a successful crop in years of normal rainfall. Alfalfa, however, is not grown extensively. There are a few orchards on this type, but most of those observed in the course of the soil-survey field work were in a run-down condition.

Wheat on this type yields about 15 to 35 bushels an acre, corn 35 to 50 bushels, oats about 25 to 40 bushels, and prairie hay about three-fourths ton. Alfalfa is cut four times a season and yields about three-fourths ton per cutting. Kafir and feterita do well.

This type is easily handled, only comparatively light implements and draft animals being necessary. The soil dries out quickly after rains but does not bake or clod badly. It is responsive to manurial treatment, and is easily maintained in a productive condition.

The present selling value of land of the Crawford silt loam ranges from about \$50 to \$100 an acre.

Yields upon this soil can be improved by deeper plowing. While the soil is in general well supplied with organic matter, a rotation including some leguminous crop would doubtless prove beneficial.

Crawford silt loam, shallow phase.—The surface soil of the shallow phase of the Crawford silt loam is a reddish-brown silt loam ranging from 2 to about 10 inches in depth. The subsoil consists of a dull-red, rather friable clay extending to the underlying limestone. This phase comprises those areas of Crawford silt loam in which limestone is encountered within the 3-foot section. The depth to this stratum ranges from a few inches to about 30 inches.

This phase occurs in small areas throughout the county. It usually occupies narrow strips along or near the limestone ledges and escarpments bordering streams. Typical areas are encountered along the west bank of the Walnut River near Winfield. The surface is in general nearly level.

Agriculturally this phase is unimportant, on account of its small total acreage and the shallowness of the soil, as a result of which both the crops and native grass suffer from lack of moisture. It is used largely for pasturing stock.

DERBY FINE SAND.

The Derby fine sand consists of a light-brown to brown fine sand, slightly loamy in places, passing at a depth of about 10 to 15 inches into yellow to yellowish-brown, loose fine sand. In the substratum reddish material is encountered, but this is not reached within the 3-foot section. The sand shows considerable mineralogical complexity, containing much more material other than quartz than do such clean sand types as the Norfolk sand of the Coastal Plain region. The material is not so loose or light colored as that of the Arkansas sands, which are encountered principally in dunelike areas in the Arkansas River bottoms.

The Derby fine sand occurs northwest of Arkansas City and near Sand Creek School, on the uplands adjacent to or near the Arkansas River bottoms. The surface is billowy or undulating to dunelike. The soil appears to consist of material blown up from the river bottoms in the same manner as that giving rise to the dunes in the bottom lands. The soil drifts considerably, even now, where clean-cultivated crops are grown, but the incorporation of organic matter has minimized drifting, so that crops are safely grown over parts of the type. The drainage is thorough, but this soil is said to conserve moisture well in dry seasons. It is light textured and is easily cultivated.

The type is not important in the agriculture of the county, because of its small extent, but it is highly prized locally for the growing of sweet potatoes, watermelons, cantaloupes, cucumbers, peaches, apples, and blackberries, to which crops it is apparently well suited. Market gardening constitutes the principal type of farming, sweet potatoes and watermelons being apparently the most important crops. Some kafir and corn are grown. In the vicinity of Arkansas City the type is mostly under cultivation to sweet potatoes and watermelons. There is one commercial apple orchard here, Ben Davis, Jonathan, Grimes, and Winesap being the leading varieties grown. The area of the type near Sand Creek School is largely used for pasture. The principal tree growth is blackjack oak and wild plum.

Sweet potatoes on the Derby fine sand yield about 100 to 150 bushels per acre in good years, and occasionally larger yields where a liberal application of barnyard manure is made.

Near Arkansas City land of the Derby fine sand is valued at \$125 an acre, but elsewhere it is held at lower prices.

In order to maintain this soil in its best condition it is necessary to keep it well supplied with vegetable matter, which can be done either by applying barnyard manure or by turning under green crops. Such treatment not only makes the soil more productive but also tends to prevent drifting.

DERBY FINE SANDY LOAM.

The Derby fine sandy loam consists of a brown loamy fine sand to fine sandy loam, underlain at a depth of about 8 to 12 inches by a lighter brown fine sandy loam which passes into more compact, yet friable, fine sandy clay of a reddish-brown to dull-red color. There are included with the type some small areas of soil having a yellowish color and resembling soils of the Knox series. These occur nearest the Arkansas River lowlands.

The Derby fine sandy loam occurs along the uplands bordering the Arkansas River bottoms. Arkansas City is situated almost entirely on an area of this type of soil. Other developments occur northwest of Arkansas City, 2 miles east of this place, northwest of Tannehill School, northwest of Hill View School, near Ninnescah School, and west and southwest of Silverdale. The surface of the type is in general gently rolling, but in some places, where the soil has drifted badly the surface is billowy. The drainage is good.

This is the only upland soil that is well forested. The area southwest of Silverdale is thickly covered with scrub oak, blackjack oak, and underbrush.

The Derby fine sandy loam is unimportant because of its small extent. It is productive and is said to resist drought remarkably well. The soil is loose and is easily tilled. The principal crops grown are corn, kafir, peanuts, melons, sweet potatoes, berries, and other truck crops. Sweet potatoes are probably the most important product. The yield ranges from 75 to 150 bushels per acre. Most of the crop is sold in the local market, but a part is shipped from the county. Corn, wheat, and kafir make slightly lower yields than on the Derby silt loam.

Land of the Derby fine sandy loam is valued at \$75 to \$100 an acre, the higher price being asked for those areas near Arkansas City.

This soil is deficient in organic matter and could be greatly improved by plowing under green crops, preferably legumes. Where the organic supply is not maintained, the soil of clean-cultivated fields is subject to drifting.

DERBY LOAM.

The typical Derby loam consists of a brown, mellow loam underlain at a depth of about 8 to 12 inches by a lighter brown, friable clay. This brownish clay grades into a reddish-brown to reddish-



FIG. 1.—WHEAT ON OSWEGO SILT LOAM IN THE SOUTHWESTERN PART OF THE COUNTY.
Plowing before the preceding crop has been thrashed.



FIG. 2.—DUNELIKE TOPOGRAPHY OF THE ARKANSAS FINE SAND.

yellow, friable clay which is more compact in the lower part. There are included with the type areas in which the subsoil is a yellowish-brown, friable clay that becomes compact below and has a large content of small, cream-colored particles. These inclusions represent a soil which closely resembles soils of the loessial Knox series.

The Derby loam occurs in the uplands near the Arkansas River bottoms. The largest areas are encountered northwest of Arkansas City, 2 miles southwest of Tresham, 1 mile southwest of Easterly School, and 4 miles south of Udall. Other, smaller areas occur along the uplands bordering the river bottoms. The topography resembles that of the Derby silt loam, with which type the loam is closely associated. The drainage is good.

The Derby loam is not an extensive type, but it is mostly in cultivation. The principal crops are wheat, corn, oats, alfalfa, melons, sweet potatoes, and fruit. Crop yields are about the same as on the Derby silt loam, possibly a little lower. The two soils are handled in much the same manner.

The general methods of soil improvement that produce good results on the Derby fine sandy loam and silt loam can be applied equally well to this type.

DERBY SILT LOAM.

The Derby silt loam consists of a brown, mellow silt loam which passes at a depth of about 12 to 15 inches into a lighter brown to reddish, friable silty clay loam, this grading beneath into reddish-yellow or reddish-brown, more compact clay loam or silty clay. The subsoil is more friable than that of the Crawford silt loam to the 3-foot level. This soil overlies limestone, but this material occurs at such depths that it apparently has not affected the soil; in road cuts the depth is seen to be 15 or 20 feet.

There are included with the Derby silt loam, especially along the bluff or slope immediately fronting the Arkansas River bottoms, some areas in which the soil closely resembles the silt loam of the Knox series, being more silty and friable than typical and distinctly yellowish in the subsoil. The soil here consists of a brown, mellow silt loam underlain at about 12 to 15 inches by yellowish-brown, friable silt loam to silty clay loam, with some faint gray mottling in the more compact lower subsoil or substratum. Farther away from the bottoms the subsoil becomes more compact, such areas representing a gradation toward the Gerald or Summit series. A development of Derby very fine sandy loam is included with the silt loam type. This coarser textured soil occurs at the base of the bluff occupied by the silt loam type, adjacent to the Arkansas River bottoms, beginning about three-fourths mile north of Gutherie School

and paralleling the Kansas Southwestern Railway in a northwesterly direction for about 2 miles.

The largest areas of the Derby silt loam are encountered immediately west and south of the Arkansas River lowlands, $2\frac{1}{2}$ miles east of Arkansas City, both north and south of Tannehill School, and north of Kellogg. It occurs elsewhere in scattered areas adjacent to the Arkansas River bottoms.

This type on the whole has an undulating to gently rolling topography, but some level or nearly level areas occur. The drainage is good.

The Derby silt loam is one of the best of the upland soils and most of it is under cultivation. The type covers only a very small part of the county, but it is locally important. The leading crop is wheat, followed by corn, alfalfa, oats, kafir, and related crops, fruit, and truck, including melons and berries. Wheat, fruit, and truck are the principal market products, the other crops being used largely as feed for beef cattle and hogs, dairy animals, and work stock.

Wheat yields about 18 to 35 bushels an acre, corn 30 to 75 bushels, and alfalfa four cuttings of about three-fourths to 1 ton each. Fruit trees do exceptionally well on this type, but there are no commercial orchards, although a number of farmers sell some fruit. Melons and berries are successfully grown.

With the exception of the sandy upland soils, the Derby silt loam is easier to till than any other of the upland types. It is plowed easily and does not clod badly, light implements and teams effecting good cultivation. The topography is favorable to the use of all kinds of improved farm machinery. The soil responds readily to manuring, and manure is used by some farmers. Commercial fertilizers are not employed. Land of the Derby silt loam sells for \$75 to \$125 an acre.

This is a very productive soil. It is well suited to the growing of fruit, closely resembling the loessial soils along the Missouri River, which produce an excellent quality of fruit, especially apples.

Alfalfa is another crop which should do well, and small fruits, berries, and potatoes can be grown successfully.

OSAGE SILT LOAM.

The typical Osage silt loam consists of a black or nearly black, mellow silt loam, underlain at a depth of 8 to 12 inches by a dark-brown to black silty clay loam. This material passes quickly into a dark-brown to nearly black, compact clay that grades below into a yellowish-brown to dark-brown clay. In narrow strips occupying a slightly higher position than typical the surface layer is brown or dark brown, the soil in such areas representing the Verdigris silt

loam, the brown equivalent of the Osage. No separation is made in this survey between the Verdigris and Osage soils owing to the small area of the former.

The Osage silt loam occurs in the first bottoms of practically all the larger streams of the county. It is most extensively developed along Walnut River northeast of Arkansas City. Other important areas occur along Dutch, Grouse, Silver, and Timber Creeks. The type occurs in strips ordinarily one-fourth to one-half mile in width. It has a level surface. The type is subject to overflows. These, however, are not frequent and between periods of inundation or of heavy rains the drainage is good.

The Osage silt loam is an important soil. It is one of the most productive types in the county, and much of it is in cultivation. A few small areas are forested, the growth consisting predominantly of elm, walnut, pecan, and sycamore.

Alfalfa, corn, wheat, and oats are the principal crops. Live stock raising is unimportant on this type, but practically every farmer raises a few hogs, colts, and calves. The wheat and part of the alfalfa produced are sold. The other crops are used largely to feed the farm stock.

Alfalfa, corn, and wheat give about the same yields as upon the Osage silty clay loam. This type is lighter textured and much easier to handle than the Osage silty clay loam or Osage clay. It is more easily put into good tilth, and does not require as much power or as heavy implements for good seed-bed preparation.

Land of the Osage silt loam is valued at \$75 to \$150 an acre.

The low, depressed areas in this type, though of small extent, would be benefited by tile drainage.

OSAGE SILTY CLAY LOAM.

To a depth of 3 to 6 inches the surface soil of the Osage silty clay loam is a black silty clay loam, underlain by a black, heavy clay which in the lower part becomes dark drab and shows faint mottlings of dark brown or rusty brown. In some places the subsoil gradually becomes yellowish brown with increased depth. Small areas of Osage silt loam and clay are included with this type where their patchy occurrence makes separation practically impossible.

The Osage silty clay loam is situated mostly in the first bottoms of Walnut River, in strips ranging from one-fourth mile to 2 miles wide. Smaller areas occur along some of the less important streams. The surface is almost level, with a faint slope toward the stream in many places. The channel of Walnut River is rather deeply entrenched and the type lies 10 to 15 feet higher than the normal water level of the stream. Inundations occur frequently and the surface

drainage is adequate except in the lower areas, where water stands after rains.

The Osage silty clay loam is probably the most extensive bottom-land soil in the county and is an important agricultural soil. Practically all of it is in cultivation, only a very small area remaining in forest of elm, maple, sycamore, walnut, pecan, and hackberry. Alfalfa, corn, oats, wheat, and kafir are the principal crops. On the whole, stock raising is not important, although nearly all the farmers raise hogs and keep a few cows. Beef cattle are not pastured on this type, on account of the comparatively high value of the land. The Osage silty clay loam is one of the best alfalfa soils in the county and fully 75 per cent of its area is devoted to this crop. Some fields that have been in alfalfa for 15 years still produce 4 or 5 cuttings a year averaging 1 ton per acre per cutting. Corn yields 40 to 100 bushels per acre, 60 bushels being about the average. Wheat yields 20 to 30 bushels an acre, though there is a tendency to the growth of straw at the expense of grain. Oats and kafir do well. Kafir, however, is grown mainly on the upland soils and occupies only a small acreage on this type.

This soil cracks badly on drying, and when plowed while dry it turns up in hard clods. It is also difficult to handle when wet, but if plowed under favorable moisture conditions it is easily brought into good tilth. A few tractors are in use for breaking. Tillage requires heavy implements and greater draft power than on the Osage silt loam or the Arkansas River bottom-land soils. No fertilizers are used on this soil.

Land of the Osage silty clay loam sells for \$75 to \$150 an acre.

The low, depressed areas in this type could profitably be tile drained. Deeper plowing would probably result in increased yields.

OSAGE CLAY.

The Osage clay consists of a black clay of waxy, plastic structure, which passes into a black, tough, plastic clay. The subsoil often has mottlings of brown and drab, but very often it shows no change within the 3-foot section. The soil is locally known as "gumbo."

This type occurs in the first bottoms of streams, mainly the Walnut River. The largest area is encountered one-half mile north of Valley View School. Smaller areas occur southeast of Odessa School, 1 mile south of Akron, and one-fourth mile west of Rock.

The surface is flat or level, with some depressions representing the location of former stream channels. The drainage is imperfectly established, and open ditches have been constructed in many places to carry off surface water.

The Osage clay is an unimportant soil, because of its small extent. About three-fourths of the type is under cultivation, being used largely for wheat production, although some alfalfa and corn are grown. The raising of live stock is unimportant. Wheat tends to produce an excessive growth of straw, but yields of 20 to 30 bushels an acre are reported. Corn yields average about 40 bushels per acre. Alfalfa does well where the land is properly drained.

This soil is tough, intractable, and heavy. It is difficult to handle, requiring heavy implements and strong draft power. It usually pulverizes easily when plowed under proper moisture conditions. If plowed when too wet the soil is likely to bake and clod badly upon drying. In hot, dry summers the clay cracks badly. Manure and lime are applied on this type to some extent.

Land of the Osage clay is held at somewhat lower prices than those asked for the Osage silt loam or silty clay loam. It sells for about \$75 to \$100 an acre.

Much of the type would be improved by tile drainage. Applications of barnyard manure would be beneficial.

ARKANSAS FINE SAND.

The surface soil of the Arkansas fine sand consists of about 10 to 18 inches of light-brownish, loose fine sand, passing below into yellowish or grayish, loose fine sand. In places the surface soil contains considerable silt, approaching in texture a loamy fine sand. Small, intricately associated areas of sand and fine sandy loam are included with this type as mapped, in addition to two small areas of Arkansas loamy coarse sand, one situated about 1 mile west of Albright, where the Atchison, Topeka & Santa Fe Railway crosses the Sumner County line, and the other one-half mile southwest of Hill View School.

The Arkansas fine sand occurs in the first bottoms of the Arkansas River, typically occupying strips parallel and adjacent to the river channel. Smaller, isolated developments are scattered irregularly in areas of the other Arkansas soils. Large bodies of the Arkansas fine sand are encountered south of Arkansas City, northeast of Geuda Springs, west and south of Hill View School, and west of Jackson School.

The topography varies from level to dunelike (see Pl. II, fig. 2). The soil deposited by the river probably had a nearly level surface, and the present hummocky topography is the result of wind action. The dunelike areas support a growth of scrub and blackjack oak and wild plum. The type is subject to overflows, but these are infrequent. For the most part it is well drained, the rainfall sinking rapidly into the loose fine sand. The soil, however, is but slightly droughty.

The Arkansas fine sand has a larger acreage than any other member of the series, and about two-thirds of it is cultivated. The most important crops grown are watermelons, cantaloupes, corn, peanuts, fruit, truck, kafir, and sorghum. Only a little live stock is kept on this type.

Watermelons mature earlier on this type than on any other in the county. They are grown for sale at local markets. Large yields are obtained, and the fruit is said to have an exceptionally good flavor. Corn yields 15 to 35 bushels an acre, and kafir and sorghum do well. Peanuts and sweet potatoes, which are grown for home use and for sale at local markets, yield well.

This soil is very easy to cultivate, but drifts badly in clean-cultivated fields, unless the organic-matter supply is maintained. Many of the farmers on this type of soil use barnyard manure.

Land of this type is valued at about \$30 to \$75 an acre. It is held at the highest figures where used for truck and fruit growing.

The Arkansas fine sand in its natural state is very low in organic matter and is benefited to a marked degree by incorporating barnyard and green manures. Drifting can be largely prevented by the use of cover crops.

ARKANSAS FINE SANDY LOAM.

The surface soil of the Arkansas fine sandy loam is a brown to dark-brown fine sandy loam, passing at a depth of about 8 inches into light-brown or brown fine sandy loam, and this at about 24 inches into yellow or yellowish-brown sand to loamy fine sand. There are some included patches of fine sand, sandy loam, and loam which merge gradually into the fine sandy loam.

The Arkansas fine sandy loam is developed in the first bottoms of the Arkansas River. The larger areas occur southwest of Kellogg, 1 mile north of Lone Star School, and south of Sand Creek School. The type is also encountered extensively along both sides of the river from Geuda Springs to the Kansas-Oklahoma line. In many places the type stands slightly higher than the surrounding soils. The topography is level to gently undulating, and the drainage is good.

The Arkansas fine sandy loam is an important bottom-land soil. The greater part of it is in cultivation, being devoted mainly to the production of corn, wheat, alfalfa, kafir, sweet potatoes, and peanuts. It is especially adapted to truck crops and fruits, principally apples. Berries do well. Practically **all** the products are sold in the local markets. The live-stock industries are almost undeveloped on this type. A few cows, hogs, and horses are raised.

Yields are practically the same as those obtained on the Arkansas very fine sandy loam, except in the case of corn, alfalfa, and wheat,

which give slightly lower yields. The land is not held at as high prices as the Arkansas very fine sandy loam.

The methods of soil improvement successful on the Arkansas very fine sandy loam can be applied with good results to the fine sandy loam.

ARKANSAS VERY FINE SANDY LOAM.

The surface soil of the Arkansas very fine sandy loam is a brown, mellow very fine sandy loam 18 to 20 inches deep. The subsoil typically is a lighter colored, friable very fine sandy loam, but it is variable, in some places consisting of a very fine sandy clay and in other places being an almost pure fine or very fine sand. The substratum, as in the other Arkansas soils, consists of sand and gravel.

This type occurs in the first bottoms of the Arkansas River. Some of the larger areas are situated southwest and south of Sand Creek School and south of Lone Star School. The type is closely associated with the Arkansas fine sand, fine sandy loam, loam, and silt loam, and areas of it occur irregularly among the other soils of the Arkansas series. The topography is level, as a rule, but there are some faint ridges or swells.

In extent, this soil is second to the Arkansas fine sand. It is the most important soil of the Arkansas series from an agricultural standpoint. At least 80 per cent of it is in cultivation. Alfalfa, sweet potatoes, peanuts, corn, wheat, melons, fruit, and vegetables are grown. No live-stock industries have been developed to any important extent, although a few small dairy herds are kept, the cream being sold locally, and a few hogs, colts, and calves are raised.

Truck crops mature earlier on this type than on the heavier bottom soils. Practically all the produce, except part of the apples, is sold at local markets. Corn yields 15 to 45 bushels per acre, and wheat 10 to 25 bushels. Alfalfa gives four cuttings, yielding one-half to 1 ton per acre each. Melons, peanuts, sweet potatoes, and a number of vegetables and fruits produce good yields.

This soil is easily handled. It can be plowed with light teams and implements and a good seed bed is easily prepared. On a few farms barnyard manure and an occasional crop of alfalfa are turned under to improve the soil.

Land of the Arkansas very fine sandy loam is valued at \$50 to \$100 an acre.

This soil, in places, has been farmed for long periods without the rotation of crops or the turning under of green-manure crops and the organic-matter content has been lowered. This has resulted in a perceptible decrease of crop yields. In such fields it would be advisable to practice a system of crop rotation, including a green manuring crop, preferably a legume.

ARKANSAS LOAM.

The Arkansas loam consists of a dark-brown to black loam, grading at a depth of about 8 inches into a brown, friable, compact loam, which in turn passes into a brown to yellowish-brown, rather stiff clay. In the lower part of the 3-foot section the content of sand increases and the subsoil becomes somewhat friable. Areas in which the soil and upper subsoil are almost black represent Osage or Lincoln loam or an approach to these types. In places sand has been blown over the surface and here the soil is generally a brown or grayish-brown fine or very fine sandy loam.

The Arkansas loam occurs in the first bottoms of the Arkansas River. Some of the larger areas are situated west and north of Jackson School, three-fourths mile west of Kellogg, near Hill View School, 2 miles southwest of Tannehill School, northeast and southeast of Lone Star School, and in the southeastern part of Arkansas City. Other smaller areas are scattered irregularly along the river.

Much of the Arkansas loam lies adjacent to the upland and in such situations it is higher than the other bottom-land soils. The type has a level to gently undulating topography. Where it adjoins the upland the land is often made wet and soggy by seepage water from the higher lying soils. In the lower situations the type is subject to overflows, but these are not frequent. The drainage on the whole is fair.

This type is about equal in extent to the Arkansas fine sandy loam and silt loam. Most of it is in cultivation, being used mainly for the production of corn, alfalfa, wheat, kafir, and oats. The live-stock industries are practically restricted to the production of pork and the keeping of small dairy herds.

All crops do well in years of sufficient rainfall. Corn yields 20 to 50 bushels and wheat 15 to 35 bushels per acre. Alfalfa gives four cuttings of one-half to 1 ton each. Kafir and oats make satisfactory yields. Fruits and vegetables, grown for home use, are less successful than on the Arkansas fine sandy loam and very fine sandy loam.

The surface soil often tends to bake, and hard, compact clods are turned up if the land is plowed wet. Under proper moisture conditions it is easily plowed and put in good tilth. The type is very productive, and is apparently maintained in this condition by applying stable manure and incorporating such vegetable matter as grass, cornstalks, and straw.

Land of the Arkansas loam is valued at about \$60 to \$100 an acre. Tile drainage would be beneficial in the low, wet places.

ARKANSAS SILT LOAM.

The Arkansas silt loam consists of a brown to dark-brown, mellow silt loam, grading at a depth of about 8 to 10 inches into light-brown or yellowish-brown silty clay, which becomes tough and compact at lower depths. At a depth of 28 to 30 inches this brownish clay passes into yellowish clay, containing enough fine sand to make this lower material somewhat more friable than the overlying material. This type is closely associated with the Arkansas very fine sandy loam and loam, and small areas of each of these coarser textured types may be included with the silt loam in places where the boundary between the soils had to be arbitrarily drawn.

The Arkansas silt loam occurs in the first bottoms of the Arkansas River. It is most extensively developed one-half mile south of Sand Creek School, one-half mile southeast of Jackson School, 1 mile west of Tannehill School, and 2 miles southeast of Geuda Springs. Smaller areas occur irregularly throughout the bottoms. The topography is level to gently undulating, and the drainage is good.

This type is of about equal agricultural importance with the Arkansas fine sandy loam and loam. About 75 per cent of it is under cultivation. The same crops are grown as on the Arkansas loam, and the yields are practically the same under similar methods of farming. Stock raising has not been developed.

Land of the Arkansas silt loam is handled in practically the same manner as that of the loam, and the selling price of the two types is about the same.

ARKANSAS CLAY.

The Arkansas clay consists of a very dark brown to black clay, underlain at a depth of 10 to 15 inches by brown to yellowish clay and at about 20 inches by yellowish sandy clay. In places the lower subsoil consists of a yellowish very fine sandy loam, passing into fine sand. The clay subsoil sometimes extends to a depth of 36 inches, where sand of different shades of yellow and brown is encountered. In digging wells a substratum of sand and gravel is encountered at varying depths. In the northeastern quarter of sec. 7, T. 35 S., R. 5 E., a small patch of Arkansas silty clay loam is included with this type. Small areas of loam and clay loam also are included. In places where sand has been blown over the surface other soils of various textures have been formed. These areas are either so intricately mixed or of such small extent that it is impracticable to separate them.

The Arkansas clay is developed in the first bottoms of the Arkansas River, usually occupying narrow strips along drainage ways or in depressed areas. Some of the larger areas occur near Jackson

School, northeast of Axley Ford, northwest of Arkansas City, 3 miles southeast of Geuda Springs, between the Kansas Southwestern Railroad and the Arkansas River, and 1 mile northwest of Hill View School.

The surface of the Arkansas clay varies from flat to depressed. It is imperfectly drained, though in places where the subsoil is of sand the soil water passes downward rapidly.

This type is unimportant because of its small extent and its rather low agricultural value. Owing to the wet, soggy character of the type only a small percentage of it is in cultivation. In its natural state it supports a dense growth of coarse grass, which is cut for hay. Small areas are devoted to wheat and corn, which give fair yields where the land is properly drained.

This soil is extremely heavy in the surface layer. Notwithstanding this, on account of its tendency to be wet for long periods, it is often plowed when the moisture content is excessive, and hard, intractable clods are formed upon drying. When the type is handled while neither too wet nor too dry it breaks up into a fairly mellow tilth. This type would be materially benefited by tile drainage.

CANADIAN SILT LOAM.

The surface soil of the Canadian silt loam is a brown, mellow silt loam underlain at a depth of 10 to 12 inches by a yellowish-brown to light-brown silty clay loam, which passes below into yellowish-brown or chocolate-brown, friable clay. In places the subsoil shows a faint reddish cast. As mapped, the type includes a small development of Canadian very fine sandy loam in the southeast quarter of sec. 6, T. 35 S., R. 4 E., and a small area of Canadian silty clay loam just to the east of Akron.

The Canadian silt loam occupies low terraces along nearly all the larger streams of the county, only a few small areas, however, being encountered along the Arkansas River. The type is best developed along the Walnut River northwest and southeast of Winfield.

A few large areas occur along Grouse, Silver, Timber, and Dutch Creeks. The surface in most places is level, with occasionally a slight upward slope toward the uplands. In some places along streams cutting through the terraces from the uplands the type has been washed or gullied slightly. Along the base of the uplands the type here and there includes strips of colluvial material. It lies above overflow and is well drained.

The Canadian silt loam is one of the most important soils of Cowley County. Practically all of it is farmed, probably 50 or 60 per cent of the total area being devoted to alfalfa. This crop is grown

largely as a source of income, but a part of it is used to feed the work stock on the farm. Corn, wheat, and kafir and other grain sorghums also are common crops. About $1\frac{1}{2}$ miles north of Winfield a nursery is maintained on this soil. Although the type is used mainly for hay and grain production, live-stock farming, consisting of the raising of hogs and the feeding of steers, is also carried on to some extent. Dairying is practiced in a small way.

Alfalfa affords four, and occasionally five, cuttings a year, the total yield being about 4 or 5 tons an acre. Corn yields 35 to 75 bushels per acre, and wheat about 15 to 30 bushels. Other crops, including oats, clover, potatoes, sorghum, apples, peaches, and small fruits, are very successful.

The soil of the Canadian silt loam is easily tilled and does not clod or bake badly. No commercial fertilizer is used, but barnyard manure is occasionally applied thinly over alfalfa fields. The soil is highly productive, but responds readily to manurial treatment.

The Canadian silt loam is a valuable soil, being especially important in the vicinity of Winfield, where it sells for \$75 to \$125 an acre. In other localities not so favorably situated with respect to markets and transportation it is held at somewhat lower prices.

At the present time the methods of farming on this type are in general good, much of the land being devoted to alfalfa, which is naturally a soil-improving crop. It is probable that hog raising and, where economic conditions are favorable, dairying could be extended to good advantage.

NEOSHO SILT LOAM.

The Neosho silt loam consists of a dark-gray silt loam, underlain at a depth of about 3 inches by an ashy-gray, powdery silt loam and at about 8 inches by a clay hardpan. This consists of a dark-brown to black, tough, heavy clay which shows no change within the 3-foot section, except that it is somewhat lighter, light brown or medium brown, in the lower part. When dry the typical soil has a light, ashy color, but it becomes darker when moist. Farmers upon this type state that a bed of sand and gravel occurs at a depth of about 30 feet.

In places the surface soil is darker colored than typical, as in a small area in the northeast quarter of sec. 9, T. 34 S., R. 4 E. Were this soil of sufficient extent it would probably be separated as the Brewer series, the dark-colored terrace group of the Great Plains region. A few small areas of Neosho silty clay loam are included with the type, mainly in the immediate vicinity of Hackney.

The Neosho silt loam occurs largely in one continuous body southwest of Winfield, occupying an apparently dead-level area, which seems to be a stream terrace. This terrace is really a low, flat area

connecting the Arkansas and Walnut River lowlands through the valley of Posey Creek. The soil is very poorly drained because of its flat topography and its dense, almost impervious, subsoil.

The Neosho silt loam is of only moderate importance in the agriculture of the county. It is used principally for wheat, although some corn, alfalfa, oats, and kafir are grown. Wheat is the money product of the farms, other crops being grown mainly for the subsistence of the stock. The live-stock industry is restricted to the raising of a few hogs, calves, and colts on most of the farms.

Yields of 25 to 30 bushels of wheat per acre have been obtained on the Neosho silt loam, but the average is about 18 bushels. Corn is grown with indifferent results, usually yielding 15 to 30 bushels an acre, though sometimes yields of 35 to 40 bushels are obtained. Alfalfa is not a very successful crop, as it is difficult to get a good stand. The ordinary yield of oats is 20 to 30 bushels per acre. Maximum yields of 50 bushels an acre have been obtained.

This soil is rather difficult to handle, especially in rainy seasons. It remains wet for long periods after rains, so as to retard plowing and harvesting, and bakes and cracks badly upon drying.

The present price of land of the Neosho silt loam ranges from \$50 to \$75 an acre.

This type of soil is low in organic matter. According to litmus-paper tests it is in an acid condition. Its productiveness could be increased by the incorporation of organic matter and where acid by applying lime. The organic-matter supply may be increased by adding barnyard manure or by turning under green vegetation. The use of ground phosphate rock or of other phosphatic fertilizer is said to have given good results on soils of this nature elsewhere. Tiling probably would improve the type.

IRRIGATION.

At the present time there is only one small irrigation plant in operation in Cowley County. This plant is situated at Albright, in the Arkansas River bottoms, and is used to irrigate nursery stock, fruit trees, and vegetables on the Arkansas very fine sandy loam, loam, and silt loam types. The water used is pumped from wells by gasoline engines. This system has been in operation only a short time. It has been found profitable in dry years.

Alfalfa, truck crops, and apple trees can probably be irrigated profitably. With the establishment of irrigation on a larger scale, a wider range of crops could be grown.

SUMMARY.

Cowley County is situated in southeastern Kansas, on the Oklahoma State line. It has an area of 1,133 square miles, or 725,120 acres.

The topography varies from gently undulating to rolling or hilly, being prevailingly gently rolling to rolling. The general slope is southwesterly. The streams have developed wide flood plains.

The elevation of the county averages about 1,150 feet above sea level and ranges from about 900 to 1,500 feet above.

The county is drained mainly by the Arkansas and Walnut Rivers and their tributaries. The surface drainage is almost everywhere good.

The population of Cowley County in 1910 was 17,582. The principal towns are Winfield, Arkansas City, Dexter, Udall, Burden, and Silverdale. The railroad facilities are good and improved highways have been built.

The county is well supplied with telephone and rural mail delivery service and good schools and churches are numerous.

Denver, St. Louis, Wichita, Kansas City, and Chicago are the principal markets, Kansas City receiving most of the live-stock shipments.

The summers in Cowley County are often hot and dry. The winters are mild, and the climate is healthful. The normal growing season is about 180 days in length. The uncertainty of the rainfall during the growing season affects the agriculture to some extent, particularly on the uplands.

The agriculture of Cowley County consists of general farming and stock raising. The leading crops are corn, wheat, oats, alfalfa, prairie hay, kafir, and feterita. Dairy farming is carried on in a small way. Hog raising and the feeding of beef cattle are important interests. Market gardening and fruit growing are developed to some extent. Alfalfa growing predominates in the bottoms, and corn, kafir, and wheat growing and stock raising in the uplands.

At present no systematic rotation of crops is practiced.

Lime and barnyard manure are the only fertilizers used.

The size of the farms ranges from a few acres to several thousand acres, averaging, in 1910, 206.3 acres. Farm land sells for \$20 to \$150 an acre. Land values are highest in the vicinity of Winfield and Arkansas City.

Cowley County lies wholly within the Great Plains region. Material residual from limestone, shale, cherty limestone, shaly limestone, and sandstone has given rise in the upland to soils of the Summit, Oswego, Gerald, and Crawford series. The soils of the upland Derby series are supposedly of wind-blown origin. The alluvial soils

are grouped in the Osage and Arkansas series, first-bottom soils, and the Canadian and Neosho series, terrace or second-bottom soils.

The Summit silty clay loam and the Gerald silt loam are the most extensive upland soils and the Canadian and Osage soils the most important and extensive bottom-land types.

The Summit stony loam is a hilly type, used either as pasture or hay land. The silt loam is largely under cultivation. The silty clay loam and its shallow phase are used extensively for the grazing of live stock, especially in the eastern part of the county.

The Oswego silt loam is a rather poorly drained soil, but practically all the type is under cultivation.

The Gerald silt loam is largely in cultivation, mainly to wheat, corn, oats, and forage and hay crops. The silty clay loam is inextensive.

The Crawford loam covers only a small total area. The silt loam, however, is extensive, particularly in the western part of the county, and is an important agricultural soil. Its shallow phase occurs only in small areas, and is used mainly for pasturing stock.

The Derby fine sand is devoted mainly to the growing of vegetables, corn, and kafir. The soil is apparently well suited to sweet potatoes, melons, cucumbers, and fruits. The fine sandy loam, loam, and silt loam are inextensive types, but they are mostly under cultivation, being used in the production of corn, kafir, vegetables, berries, and other truck crops.

The Osage silt loam and silty clay loam are productive and important soils. Alfalfa, corn, wheat, and oats are the principal crops, alfalfa occupying a large proportion of the total area of the silty clay loam. The Osage clay is a rather imperfectly drained and intractable soil, but under favorable conditions corn and alfalfa do well.

The greater part of the Arkansas fine sand, fine sandy loam, and very fine sandy loam is under cultivation. These types are used on a large scale for the growing of vegetables, but general-farming crops also are important. The loam and silt loam are devoted mainly to general farming. The clay type is rather imperfectly drained and is an unimportant agricultural soil.

The Canadian silt loam is a productive and important soil, highly prized for alfalfa, which occupies at least one-half the cultivated area.

The Neosho silt loam is of small extent. It is used mainly for wheat, with corn, alfalfa, oats, and kafir grown to some extent.

The irrigation of certain crops may prove profitable on some of the soils of Cowley County.

[PUBLIC RESOLUTION—No. 9.]

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

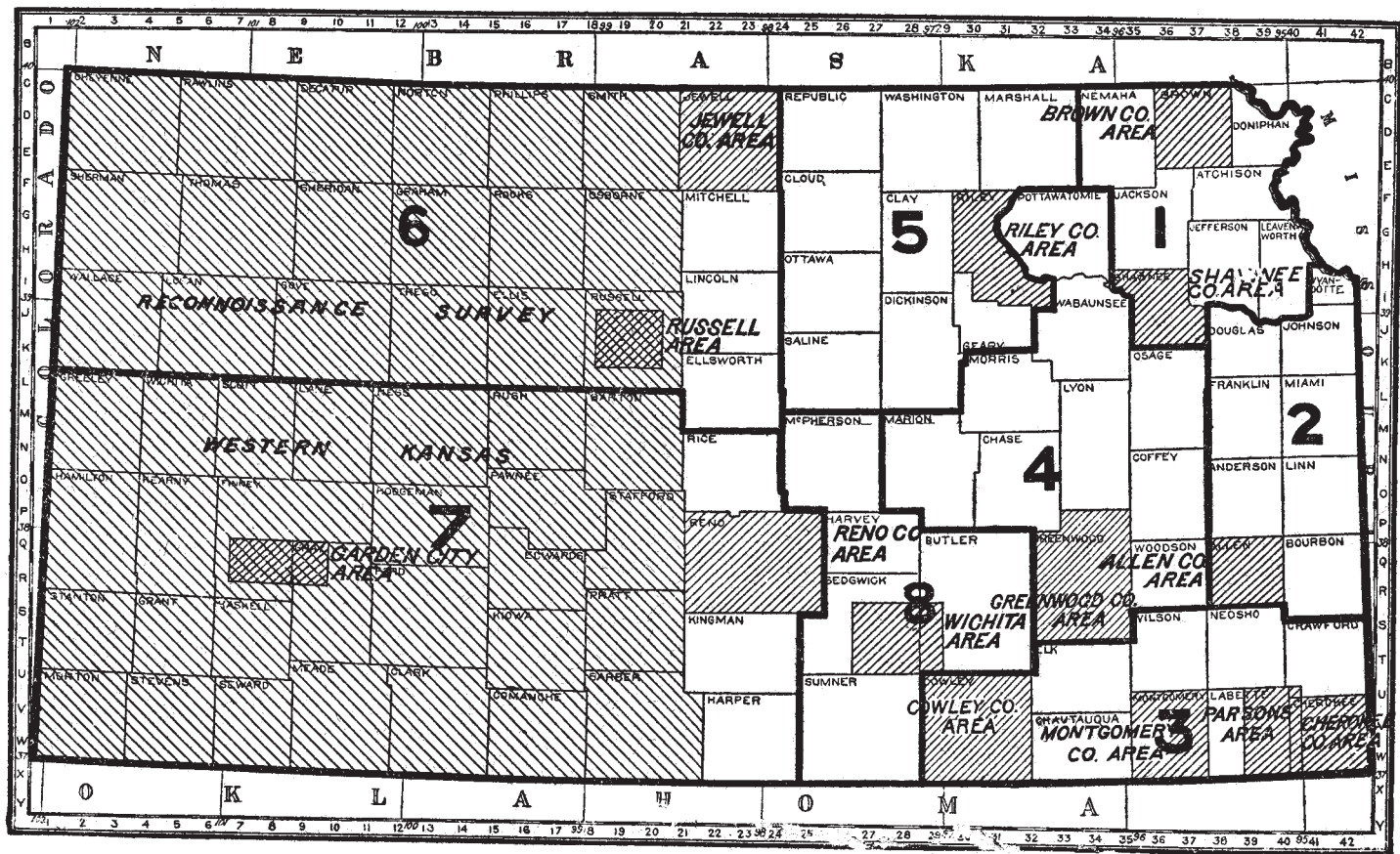
Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and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

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

Approved, March 14, 1904.

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





Areas surveyed in Kansas.

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