SOIL SURVEY OF LEAVENWORTH COUNTY, KANSAS.

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DESCRIPTION OF THE AREA.

Leavenworth County is situated in the northeastern part of the State of Kansas, about 40 miles south of the northern boundary of the State and about 15 miles west of Kansas City, the largest city in the State. The county is approximately 30 miles long north and south and 15 miles wide east and west. It has an area of 460 square miles, or 294,400 acres.

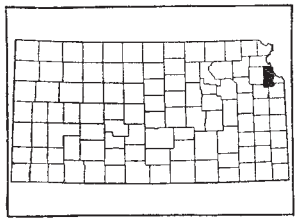

FIG. 6.—Sketch map showing location of the Leavenworth County area, Kansas.

With the exception of the comparatively narrow strips of flat alluvial land along the larger streams, the topography of Leavenworth County varies from undulating to rolling. The country was originally a comparatively flat limestone plain. This had been considerably eroded by streams before the advance of the Kansan ice sheet, which greatly modified the existing topography by planing off prominences and depositing its load of drift. Later further alteration took place by the deposition of loess. The latter deposit was rather thin and has suffered from active stream erosion.

The higher western and northern part of the county is separated from the lower eastern and southern part by a distinct limestone escarpment. The difference in elevation of these two sections ranges from 100 to 180 feet. Above the escarpment in the western and northern part of the county most of the streams have cut down into the underlying limestone and shales and have distinct V-shaped valleys. As the streams approach the escarpment, the slopes become more abrupt and are accentuated in places by outcrops of thin beds of limestone. In the northeastern part of the county, below the escarpment, the stream valleys are V-shaped, but the valley walls are well rounded, and do not become abrupt until the Missouri River is approached. The streams in the remainder of the region below the escarpment usually have V-shaped valleys with well-rounded slopes, except near the base of the escarpment, where the valleys are more U-shaped and the surface is more undulating. The

areas of alluvial land along the rivers and larger creeks are not very wide, nearly level, and, with the exception of small remnants of higher terraces, are all subject to overflow.

The elevation above sea level of the Kansas River flood plain ranges from about 800 feet near the western county line to 789 feet at Linwood and 790 feet near Loring. The range in elevation on the Missouri River flood plain is from 760 feet near Maltby to 770 feet across the river from Leavenworth, and about 780 feet near the northwestern corner of the county. The elevation of the Stranger Creek flood plain is 930 feet above sea level near the northern county line, about 860 feet near Jarbalo, and about 790 feet near Linwood. The general elevation of the land above the Oread escarpment ranges from 1,000 to 1,100 feet, and that below the escarpment from 850 to 1,000 feet above sea level.

The county lies within the drainage basins of the Missouri and Kansas Rivers. The Missouri River flows along the northeastern border and drains only the northeastern quarter of the county. Its most important tributaries are Salt and Plum Creeks, each of which is about 8 miles long. The other tributaries are short and have a moderately swift flow.

The Kansas River flows along the southern boundary of the county. Its principal tributary is Stranger Creek, which divides the county near the middle from north to south. Important tributaries of Stranger Creek are Ninemile, Tonganoxie, Fall, and Walnut Creeks to the west, and Rock and Little Stranger Creeks to the east. These creeks, which have a continuous flow in their lower courses, have rather swift currents. Above the limestone escarpment the minor tributaries, which reach every farm, have very swift currents and are actively cutting their channels deeper. The main creeks lie from 100 to 160 feet below the general level of the uplands from one-half to 1 mile inland. Below the escarpment the main streams lie from 50 to 80 feet below the general level of the uplands, and the currents of the smaller tributaries are not as swift as those of similar tributaries above the escarpment, being rather sluggish near the base of the escarpment, especially west of Stranger Creek. While the ramifying branches are not as numerous in this region, they reach every farm.

In the upland, water is usually obtained in open dug wells at depths ranging from 30 to 60 feet. Drilled wells go to greater depths. On alluvial lands sufficient water is often obtained in wells from 20 to 30 feet deep.

The territory of Leavenworth County was originally included in the Delaware, Muncie, Kickapoo, and Wyandotte Indian Reservations. The first white settlement in the county was made at Fort Leavenworth in 1827. The county was thrown open for settlement

by the passage of the Kansas-Nebraska act on May 30, 1854. Settlers immediately crowded in from Missouri, and others came later in the year from Iowa, Illinois, Indiana, and western Ohio. Within a year nearly every tillable quarter-section in the northern part of the county that was not included within an Indian reservation was occupied by one or more settlers. The county was organized in 1855, but was reduced in 1859 by the taking of a part of its area to form Wyandotte County.

By 1870, according to the Federal census, the population was 32,444, and the population steadily increased until 1910, when it was 41,207. There was a decline during the next decade, the 1920 returns showing only 38,402, of which 56 per cent is classed as rural. The density of the rural population is 48.8 per square mile. Nearly 10 per cent of the population is negro, and about 9 per cent is foreign born. Most of the foreigners came from Germany, Ireland, England, and Poland. There is a small settlement of Germans in the northwestern corner of the county.

Leavenworth, the county seat, is located in the northeastern part of the county. It had a population of 16,912 in 1920. Of the other more important towns, Tonganoxie, in the south-central part, had a population in 1920 of 971; Linwood in the southern part, 364; and Easton in the northwestern part, 228. Other important trading centers are Lowemont, Kickapoo, Basehor, Fairmount, Jarbalo, and Lenape. All these towns have facilities for shipping grain and live stock. Considerable farm produce from the northwestern part of the county is marketed at Potter, 1 mile north of the county line.

The county is well supplied with railroads, no farm being more than 6 miles from a railway station. The Kansas City-Omaha line of the Missouri Pacific Railroad follows the Missouri River along the eastern boundary of the county. The Kansas City-Denver line of the Union Pacific Railroad follows the Kansas River along the southern boundary. One branch of the Union Pacific Railroad traverses the south-central part of the county from Lawrence to Leavenworth, another runs from Leavenworth north and west through Easton. The Atchison, Topeka & Santa Fe Railway has a branch from Holliday and Bonner Springs along the eastern border of the county to Leavenworth, and one from Leavenworth through Lowemont and Potter toward Atchison. The Leavenworth & Topeka Railway runs south and west from Leavenworth through the middle of the county, passing through Jarbalo and Ackerland. The Kansas City Northwestern Railroad operates a line from Leavenworth south which connects with a line from Kansas City and traverses the central part of the county from east to west, passing through Tonganoxie and Neely. The Kansas City, Leavenworth & Western Railroad has an electric line for hauling freight, express, and passengers

from Leavenworth through Delaware Township to Kansas City. Another electric line traverses the southern part of the county, running from Kansas City to Lawrence.

The principal wagon roads are kept in fair condition, but little attention is paid to the less important ones. The roads follow or run parallel to section lines, except where bad grades can be avoided by following divides or streams. The road from Leavenworth to Lansing is of brick; the other roads are of earth construction. A macadam road is under construction from Lansing south to connect with a similar road that is to be built across the county from Kansas City to Fort Riley. Nearly all the stream crossings are bridged.

The rural free delivery of mail and telephone lines reach every community in the county. Rural schools are maintained at convenient distances.

Kansas City furnishes an excellent market for all farm products not used locally. Leavenworth and Tonganoxie have mills using the wheat produced in the county. A milk condensery is located at Tonganoxie, two creameries at Leavenworth, and cream-buying stations at the smaller towns in the county. A packing plant at Leavenworth utilizes much of the beef grown. Weston, Mo., across the river from Kickapoo, has a market for tobacco. Some of the live stock and grain is shipped to Atchison, Kans., and St. Joseph, Mo.

CLIMATE.

The climate of Leavenworth County is characterized by a wide annual range in temperature and rainfall, but on the whole is quite favorable for the production of small grains and hay crops, and usually for corn. An extreme temperature of 110° F., occurring in August, has been recorded by the Weather Bureau station at Leavenworth, and an absolute minimum of —22° F. in January. The mean annual temperature is 53.4° F. Corn is sometimes damaged on some of the shallower soils by hot winds.

The climate is humid, the mean annual rainfall averaging 34.74 inches. The wettest months ordinarily are May, June, and July, and over 70 per cent of the precipitation occurs during the growing season, April to September, inclusive. The wettest year on record (1858) had a rainfall of 59.65 inches, the driest (1864), 14.60 inches. Total crop failures are unknown, though the yields of crops that make their growth during the summer months are occasionally diminished by drought and hot winds. Snow rarely remains on the ground for any great length of time.

The average growing season is about 187 days, which is long enough to insure the successful production of the ordinary farm

crops. The average date of the first killing frost in the fall is October 14 and of the last in the spring April 10. The latest recorded killing frost in the spring occurred on May 1 and the earliest in the fall on September 25. Fruit is sometimes injured by late spring frosts, especially in seasons when the buds have been prematurely developed during warm periods in late winter or early spring.

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

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

(Elevation, 745 feet.)

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1864).	Total amount for the wettest year (1858).
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*
December	31.2	66	−9	1.37	0.07	2.11
January	27.4	65	−22	1.11	1.00	2.38
February	31.8	73	−14	1.40	0.00	2.10
Winter	30.1	73	−22	3.88	1.07	6.59
March	40.8	90	4	1.88	0.89	1.00
April	54.4	88	24	2.88	0.97	2.62
May	64.6	99	35	4.48	0.95	5.00
Spring	53.2	99	4	9.24	2.81	8.62
June	73.4	104	48	5.02	0.26	8.77
July	77.0	104	53	4.23	1.73	10.57
August	76.2	110	45	4.15	1.60	7.26
Summer	75.5	110	45	13.40	3.59	26.60
September	67.4	102	31	3.77	3.66	8.28
October	56.0	91	19	2.43	2.00	5.66
November	41.5	82	5	2.02	1.47	3.90
Fall	54.9	102	5	8.22	7.13	17.84
Year	53.4	110	−22	34.74	14.60	59.65

AGRICULTURE.

A good growth of prairie grass originally covered about 90 per cent of the surface of Leavenworth County. The slopes and the bottoms in the more rolling sections of the county supported a forest

growth, consisting chiefly of white oak, bur oak, black oak, walnut, cottonwood, hackberry, elm, ash, wild cherry, sycamore, and maple. The forest was not as thick as at present, owing to the prevalence of prairie fires which destroyed the young trees. It is said that most of the present growth is less than 35 or 40 years old.

The first attempt at producing field crops in the county was on the United States military reserve soon after its establishment in 1827. The first extensive development of agriculture was immediately after the opening of this territory for settlement in 1854. The crops at first were grown for home use and for sale to the military post. They included chiefly corn, wheat, rye, oats, and potatoes. Flax, tobacco, and sorgo (saccharine sorghum) were grown to a small extent. Early transportation was confined largely to boats on the Missouri River. Cattle raising was a very important industry because of the large open range available. Before the railroads were built the cattle were marketed at the local post or driven to Kansas City. The Union Pacific Railroad along the Kansas River, its branches from Leavenworth to Lawrence and from Leavenworth to Easton, and the Missouri Pacific Railroad were built in the sixties and seventies, and by 1878, 45 per cent of the available land in the county was under cultivation.

The most important crops and their acreage in 1872, as reported by the State Board of Agriculture, are shown in the following table:

Acreage of leading crops in 1872.

Crop.	Acres.	Crop.	Acres
Corn	43,921	Rye	579
Prairie hay	11,173	Hemp	135
Oats	8,714	Barley	107
Wheat	4,245	Buckwheat	98
Clover	2,513	Sorghum	77
Potatoes	2,005	Flax	14
Timothy	1,763	Tobacco	14
Millet	1,112		

Of these crops, hemp, buckwheat, and flax are the only ones not produced on a considerable acreage at the present time. The acreage of hemp was at a maximum about 1875, when 275 acres were devoted to this crop. Flax was planted on the newly broken prairie land, and as more of the land was put under cultivation its production decreased. Probably the largest acreage devoted to flax was 1,583 acres in 1881.

The following table shows the acreage, total yield, and yield per acre of the most important crops for census years from 1879 to the present time:

Acreage, total yield, and yield per acre of selected field crops, as reported by the Federal census.

Year.	Corn.			Wheat.			Oats.			Potatoes.		
	Area.	Yield.	Per acre.	Area.	Yield.	Per acre.	Area.	Yield.	Per acre.	Area.	Yield.	Per acre.
	Acres.	*Bushels.*	*Bu.*	*Acres.*	*Bushels.*	*Bu.*	*Acres.*	*Bushels.*	*Bu.*	*Acres.*	*Bushels.*	*Bu.*
1879	53,910	1,785,976	33.1	27,786	418,211	15.1	6,637	188,816	28.4	.....	98,393	.....
1889	50,582	1,803,935	35.6	20,245	366,099	18.1	15,062	403,783	26.8	3,291	264,828	80.4
1899	69,313	2,172,040	31.3	24,147	312,720	12.9	4,944	135,920	27.5	4,987	604,651	121.3
1909	58,960	1,574,618	26.7	37,425	598,779	16.0	8,018	199,976	24.9	3,043	237,065	78.0
1919	29,405	666,035	22.7	76,049	1,262,030	17.0	8,892	194,250	21.9	2,163	142,726	66.0

Year.	Alfalfa.			Tame or cultivated grasses.			Wild grasses.		
	Area.	Yield.	Per acre.	Area.	Yield.	Per acre.	Area.	Yield.	Per acre.
	Acres.	*Tons.*	*Tons.*	*Acres.*	*Tons.*	*Tons.*	*Acres.*	*Tons.*	*Tons.*
1879	.....	.....	.....	[1] 17,826	19,202	1.1	.....	.....	.....
1889	.....	.....	.....	[1] 34,089	47,547	1.4	.....	.....	.....
1899	212	458	2.1	[2] 26,181	40,437	1.6	8,033	9,627	1.2
1909	2,899	7,985	2.8	[2] 17,541	22,194	1.2	5,066	6,908	1.2
1919	9,209	21,521	2.3	[2] 10,494	14,131	1.3	4,172	4,016	1.0

[1] The figures given in the census reports of 1880 and 1890 include both tame and wild hay.
[2] Figures given include acreage of grains cut green for hay.

It will be seen from this table that, with the exception of recent years, corn has always been the leading grain crop, followed by wheat and oats. A small amount of cotton was produced in the early days, but its production ceased in the early eighties. Small acreages have been planted to broom corn in various years, but very little of this crop has been grown since 1900.

At the present time the agriculture of Leavenworth County consists mainly of a combination of grain and dairy farming. This system has proved quite profitable, utilizing advantageously the crops produced and maintaining the soils in a productive condition. Practically all the field crops produced, except wheat, which is the main cash crop, are used for feed. Truck farming and trucking, combined with fruit growing are important in the northeastern part of the county and along the Kansas River. The practice of feeding hogs in conjunction with dairying and grain farming is common in most parts of the county.

Until 1918, when war conditions caused a transfer of a considerable part of the corn acreage to wheat, corn was the leading crop in the county. From 1880 to that time the acreage devoted to corn remained above 50,000 acres. Most of the corn is grown from home-grown seed and nearly three-fourths is of the Boone County White variety. Reid Yellow Dent and Golden Beauty are the only other

important varieties. The Pride of Saline is highly recommended by the State agricultural experiment station for the more droughty soils of the county and has proved quite productive on the few farms where it has been tried. About two-thirds of the corn produced is fed in the county; the remainder is sold to local dealers or shipped directly to a larger market, usually Kansas City.

Wheat is the only field crop largely used as a cash crop. It has been the crop of second importance since the beginning of the agriculture of the county, but in 1919 the acreage was more than two and one-half times as large as that in corn. Practically all the wheat grown is winter wheat. The chief varieties grown, in the order of their importance, are Harvest Queen, Harvest King, Fultz, Red Wave, and Red Chaff. The Fultz was the leading variety in the early eighties. The Kanred variety, developed and highly recommended by the State experiment station for its drought-resisting qualities, has been planted by several farmers in the county during the last two years. They report that the variety is very prolific, less likely to winterkill, and gives a larger production of grain than the other varieties commonly grown. The acreage devoted to this variety was widely extended in the 1919 plantings. Practically all of the wheat produced is sold to local mills or shipped to Kansas City. Wheat is grown in all parts of the county and on all types of soil. Commercial fertilizers can be used profitably for this crop on the lighter-textured soils in the southern half of the county.[1]

Oats constitute the small-grain crop second in importance. Less than 20,000 acres are devoted to this crop in normal years. The most popular variety is the Red Rustproof. Some Kherson is grown. A new variety, recently distributed under the name Kanota, is recommended by the State experiment station for the lighter textured soils. This variety matures early and thus avoids the effects of drought. It is said to give an average production from 4 to 6 bushels larger than the other varieties grown. All the oat crop is utilized on the farms for feeding work stock, small pigs, calves, and dairy cattle. Not enough is produced to meet local needs.

The grain sorghums have occupied a larger acreage in recent years, especially on the more droughty residual soils, where they are used to replace or supplement corn in the drier years. The crop is grown both for grain and forage, and used locally for wintering stock and in making silage for dairy cattle. The most popular variety is the Blackhull White Kafir, followed by feterita and milo. Probably 90 per cent of the crop grown is of the first-named variety. Considerable Kansas Orange sorghum is grown for forage.

[1] See Bulletin 219, Kansas Agr. Expt. Sta. Growing Wheat in Kansas.

There has been an increase in the acreage devoted to tame-grass hay crops since 1910. Clover for hay was grown on 3,219 acres in 1919, timothy on 3,429 acres, clover and timothy mixed on 2,695 acres, alfalfa on 9,209 acres, and other tame grasses on 498 acres. The acreage of sweet clover is being extended each year, both for green manuring, as in the Kansas River bottoms, and for pasturage and meadow on the thinner upland soils. Sudan grass was introduced in the county about 1916. It was grown on 71 acres in 1918, but more was planted the following year. It does well on practically every soil in the county. Alfalfa can be grown on most of the soils in the county, but inoculation is usually necessary on land not previously used for the crop. It yields three or four cuttings annually. Practically all of the hay produced is fed in the county, and in some years considerable is shipped in.

Prairie hay was cut from 4,172 acres in 1919. It was fed locally. In addition, prairie grass occupies nearly 20,000 acres of pasture.

Potatoes have always been produced on a large acreage in this county. On nearly every farm enough are raised for home use. The production of this crop on a commercial scale has been most extensively developed in the Kansas River bottoms, though carried on to some extent in the vicinity of Leavenworth. The most popular varieties are the Early Ohio and the Irish Cobbler. Potatoes do best on the lighter textured, well-drained bottom soils of the county, especially where the supply of nitrogen is plentiful. Most of the crop is marketed in Kansas City. Sweet potatoes of the Nancy Hall and Dooley Yam varieties are grown to some extent.

Watermelons and muskmelons are produced on a small commercial scale in the Kansas River bottoms. They do well on the lighter bottom soils. Market gardening is a specialized industry on the loessial soils in the vicinity of Leavenworth, where practically all the common vegetables are produced in large quantities, especially sweet corn, tomatoes, and cucumbers. The product has a ready market in Leavenworth and near-by towns. No commercial fertilizers are used in truck farming, but the best truckers apply liberal quantities of barnyard manure annually, or turn under a green-manuring crop.

Orchards have been planted on a commercial scale in Leavenworth County for over 40 years. The number of fruit trees reported in the 1920 census is as follows: Apple, 91,921; peach, 11,649; cherry, 10,937; pear, 9,657; and plum, 4,018. Apples have always been the most important fruit. The leading varieties grown are the Jonathan, Blacktwig, Winesap, and York Imperial. One apple orchard in the western part of the county contains nearly 800 acres. Several scattered over the northern half of the county contain from 20 to 80 acres.

The apple does best on the loessial and glacial soils. Until recent years but little attention was paid to the care of many of the orchards, and their bearing was very irregular, netting the owner a profit about one year in every three or four. Within the last two years (1917 and 1918), many have renovated their trees and sprayed them scientifically for diseases and insect pests, and as a result are reaping profitable yields consistently. The fruit is usually contracted for by Kansas City buyers. Many small farm orchards are maintained. These ordinarily include apple, peach, cherry, and plum trees. Next to apples, cherries are the most popular fruit. The yield of peaches is very uncertain, because of climatic conditions and disease. Plums do well. Many small orchards of pears have been planted in recent years. The most popular varieties are the Kieffer and the Garber. The Concord is the most common variety of grape, and a number of small vineyards of this sort are located in the northeastern part of the county. Strawberries, blackberries, and raspberries are grown to a considerable extent in the vicinity of Leavenworth. Some nursery stock is grown on the loessial soils near Leavenworth.

The leading branch of the live-stock industry in Leavenworth County is dairying. It has always received considerable attention, but has become more important since the establishment of a condensery at Tonganoxie, which stimulated the desire for better milk-producing types of cattle. There are 9,337 milk cows in the county, according to the 1920 census. The most important dairy breed is the Holstein-Friesian. Many purebred herds of this breed are found throughout the county. The cows are kept on pasture during the growing season, with some supplementary feed. In the winter months they are fed on ensilage or hay, with some concentrate. There were 214 silos in the county on March 1, 1918, and the number is increasing annually. Two or three dairymen in the county are milking over 100 cows the year round. Most of the farmers keep several milk cows in conjunction with grain farming. Most of the milk is sold as whole milk to the condensery at Tonganoxie, the two creameries at Leavenworth, the distributing companies at Leavenworth, or the cream stations in the smaller trading points. Collecting trucks traverse most of the region within 12 miles of Tonganoxie.

The raising and fattening of hogs is also an important industry. According to the census there were 23,997 hogs in the county on January 1, 1920. Most of the hogs are of mixed breeds, though a number of purebred herds are scattered over the county. The most popular breeds are the Duroc-Jersey, Poland-China, and Chester White. Hogs are usually pastured on alfalfa or clover, and many hog raisers

have obtained the best results by keeping a self-feeder of tankage before the growing pigs while on pasture. The majority of the farmers supply no concentrates until fattening and finishing time. The surplus hogs are usually shipped from the farm to Kansas City and St. Joseph, Mo.

The most popular breeds of beef cattle are the Shorthorn, Hereford, and Polled Durham. Several purebred herds are found in the central and northern parts of the county. Beef cattle are produced most extensively in those parts of the county that are more broken and less suited for cultivation. Taking the county as a whole, winter feeding and fattening of beef cattle is not practiced very extensively. A large percentage of the offspring is sold as baby beef.

There were 7,746 horses in the county on January 1, 1920, and 3,228 mules and asses. The horses are nearly all of grade breeding, with the Percheron type dominant. Nearly every farmer raises one or more colts a year, and in this way keeps up his supply of work horses and occasionally has a surplus to sell.

The 7,037 sheep reported in the 1920 census were owned in small flocks. They are of mixed breeds. A production of 20,933 pounds of wool is reported for 1919.

The table below shows the value of farm products in Leavenworth County in 1919, as reported by the census of 1920. These figures indicate the relative importance of the several classes of products. However, in comparing these figures with similar figures for other years due allowance must be made for the fact that prices in 1919 were unusually high.

The value of animals sold or slaughtered was not reported in the 1920 census. The 1910 census reported the value of this item as $947,976. The State Board of Agriculture reported the value of animals slaughtered or sold for slaughter in 1918 as $905,153.

Value of selected farm products in 1919.

Products by classes.	Value.	Products by classes.	Value.
Cereals	$3,855,898	All other crops	$10,357
Other grains and seeds	6,734	Dairy products (excluding home use)	635,124
Hay and forage	873,057	Poultry and eggs	485,464
Vegetables	504,371	Honey and wax	2,064
Fruits and nuts	263,079	Wool	9,620

More attention has been paid in recent years to the adaptation of crops to the different soils. The darker colored soils with moderately friable to friable subsoils are well adapted to all the important crops of the region; the soils with claypan subsoils are best suited to wheat, oats, grain sorghums, and grass. The Wabash soils are the best

corn soils of the county, but small grains produce too rank a growth on these soils in wet seasons. The lighter textured Sarpy soils are known as excellent alfalfa, corn, potato, and truck soils. The loessial and glacial soils are chosen for the planting of orchards. The partly weathered soils such as the Boone silty clay loam, and thin soils, such as the Crawford stony loam, are best adapted to grass. The lighter textured soils of the Boone series are known to give better results with the grain sorghums than with corn. The topography of the Crawford stony loam and the steeply rolling phase of the Knox silt loam makes them suitable only for grazing.

In recent years the necessity of rotating crops according to a definite system has become more apparent. This had been emphasized chiefly by the decrease in grain yields under the old practice of continuous cropping, and by the lack of sufficient live stock on many of the farms to supply the manure necessary to maintain the soils in a productive condition. Corn is now hardly ever grown more than 2 years in succession on the same field by the better farmers, except on the typical Summit silt loam and clay loam, the Grundy silt loam, and the alluvial soils. On these soils it may be grown 4 or even 5 years without an appreciable decrease in the yield. Corn has been grown on the alluvial lands for 20 years in succession or longer without the addition of organic matter, but this is not unusual for overflow lands. Wheat has been grown on some fields continuously for 10 to 20 years, and on the lighter textured soils the yields have noticeably decreased. Alfalfa stands are profitable for so many years on most of the soils that the introduction of this crop in rotations makes them too long. The legume used for this purpose is red clover. The most common rotation includes corn 1 year, oats 1 year, wheat 1 year, and clover 2 years. This may be modified on alluvial soils and the better upland corn soils so that corn is grown 2 years in succession, and on soils with a lighter texture or a heavy subsurface layer wheat may be grown 2 years in succession. On the thinner residual soils corn is often displaced by a grain sorghum.

In the last few years more attention has been given than formerly to the preparation of the seed bed, the selection of seed, and the cultivation of intertilled crops. A decrease in the average yield of corn and wheat on many of the thinner soils has led to the selection of drought-resistant strains and even to the substitution of more drought-resistant crops. Corn is planted on ground plowed either in the fall or in the spring. The heavier soils and bottom soils are usually plowed in the fall, because with this treatment they warm earlier in the spring. Some corn is listed on the sandier types. Corn is usually cultivated three or four times. In many cases the stalks are pastured, after the grain is husked, and a few farmers practice

"hogging down" a part of the stand early in the fall. Where wheat follows corn, the wheat may be sown between the corn rows in the fall or drilled in the stubble after the corn is removed for fodder. Oats usually follow corn, the seed bed being prepared by plowing 4 to 6 inches deep and leveling with a harrow. Wheat follows oats as a rule. The land for this crop is prepared in late summer or early fall or after the previous crop is harvested. The preparation of the seed bed is much the same as oats, though when the ground is very dry, or in places where weeds grow rapidly, the plowed ground is often disked one or more times before drilling in the seed.

Clover is often sown in the wheat in the spring, and gives one cutting of hay after the wheat is harvested. Any later growth is allowed to go to seed to improve the stand the following year. There may be some pasturage the first year if the season is favorable. The land, if pastured, is plowed early the next spring and returned to corn. If left until the second year the plowing is usually done in the fall. Timothy is sown with the wheat in the fall, and the clover added in the spring, by a few farmers. The subsequent operations are similar to those used when clover alone is sown in the wheat. Many farmers report that corn usually yields about 5 bushels more per acre the first year following clover than the second.

Small grains are usually drilled. Most of the grain crop is threshed from the shock. It is a common practice, especially on rented farms, to sell the wheat direct from the threshing machine.

Alfalfa can be grown on nearly every soil in the county, with a careful seed-bed preparation, but in most cases it is necessary to inoculate either the seed or the land. Good stands of alfalfa have been obtained from spring and also from August sowings, either giving good results if the soil and moisture conditions are favorable. The crop gives three or four cuttings a year and usually occupies the ground 7 or 8 years, or as long as the yield is profitable.

Kafir is the most common grain sorghum planted to provide grain and fodder if the conditions in the spring are unfavorable to corn. It is usually sown with a drill. Timothy is often sown broadcast in small fields to furnish hay. The native grasses are being crowded out by bluegrass. Bluegrass is usually seeded alone for pasture, and the growth is very persistent. A mixture that is used by a few farmers to give early pasturage includes bluegrass, redtop, timothy, and red clover. The bluegrass takes the land within 2 years.

Irish potatoes are often grown on the same ground many years in succession, and most of the fields have become infected with a potato-rot fungus. Considerable attention has been given in recent years

to the improvement of seed and to the curbing of fungus diseases. The best methods of treating the seed are given in Bulletin 194, by the Kansas Agricultural Experiment Station. Where potatoes are grown continuously on the same ground it is a common practice to plow under turnips as a green manure. However, a few growers have used sweet clover instead of turnips the last year or two, and state that the production was increased as much as 200 per cent.

The expenditure for commercial fertilizers in 1919 is given as $7,086, only 2.9 per cent of the farms in the county reporting their use. Much more fertilizer is being used at present than 10 years ago, because of the favorable results obtained in recent cooperative experiments conducted on the thinner upland soils by the Kansas Agricultural Experiment Station. The results indicate that the residual soils of eastern Kansas respond to applications of phosphate, especially where the soils are derived from sandstones and shales.[2] The fertilizer used most largely in the county is bone meal, which is applied at the rate of 120 to 150 pounds per acre. It is most profitable when applied to the land being prepared for wheat. In general farming the barnyard manure that accumulates during the winter months usually lies in open lots until spread on the land, and consequently loses much of its value. It is usually applied to land intended for small grain. In truck farming the manure is put on the soil as soon as practicable after it is made.

Ordinarily there is a plentiful supply of farm labor. Much of it is transient, however, and is not entirely satisfactory. The average wage[3] during the summer months is from $40 to $50 a month, including board and washing; during the winter it is lower. Day laborers receive from $2.50 to $5, depending upon the season and the character of the work to be done.

According to the 1920 census the average size of the farms in the county is 127.9 acres, of which 98.1 acres are improved. About 96 per cent of the area of the county is in farms. There are 2,115 farms in the county, of which 66.1 per cent are operated by the owners, 32.2 per cent by tenants, and 1.7 per cent by managers. From the time the county was first settled until 1900 the proportion of tenant farmers steadily increased, but the last two census reports show a slight decrease. Most of the tenant farms are rented on a share basis, with cash for hay or pasture land. The usual rent on the upland is one-third of the grain, when the tenant furnishes everything, and one-half of all the grain crops when the owner furnishes implements and seed. On the bottom land the tenant gives two-fifths of the small grain and half of the corn, when he furnishes everything, and three-

[2] Bul. 220, Kans. Agr. Expt. Sta. Soil Fertility.

[3] These wages prevailed at the time the field work was in progress (1919). At the time of going to press (1923) wages are considerably lower.

fifths of the produce when the owner supplies the implements, work stock, and seed. Cash rents range from $4 to $10 an acre for most field crops and as high as $25 an acre for alfalfa land. Pasture land rents for $8 to $10 an acre.

The prices of farm lands have a wide range. The tillable upland can ordinarily be bought for $100 to $225 an acre, unless the price is affected by location near a city or town. Bottom land along the smaller creeks has about the same value as the average upland. Bottom land along the Kansas River is held for $250 to $400 an acre.

SOILS.

The soils of Leavenworth County may be divided, according to the processes of accumulation, into four broad groups, residual, glacial, loessial, and alluvial. The residual and glacial soils are found throughout the county, the loessial soils chiefly in the northeastern part and along the Kansas River, and the alluvial soils in the river and creek bottoms.

The residual soils, that is, those derived from the immediately underlying rock, are the most extensive in the county. The formations from which these soils come consist of alternating beds of shale and limestone, with irregular beds of sandstone and some beds of coal. These beds belong to the Pennsylvania series of the Carboniferous system.[4]

The oldest beds of material contributing to the soils of the county are known as the Vilas shale and Stanton limestone of the Lansing formation.[5] These are not extensive, however, occurring only in the vicinity of Lansing and Lenape. The formation most important as influencing the soils of the county is the Douglas formation. All the members of this formation are exposed in the Oread escarpment, which starts at Fort Leavenworth, passes through the western part of the city of Leavenworth, runs southwest along the Leavenworth & Topeka Railroad, thence west to the north of Boling to Stranger Creek; across Stranger Creek the line starts at Jarbalo, goes southward to Tonganoxie, then southwest on the west side of the Union Pacific Railroad tracks. The line of this escarpment is also close to the northern and western boundary of this formation in this county. The escarpment is one of the most prominent topographic features of this part of the State. The range in elevation from the lower to the higher margin varies from 100 to 180 feet or more.

The Douglas formation is about 300 feet thick and is composed chiefly of shale. It is topped by a very persistent limestone, which is thicker than most limestone beds in this series. The beds of sand-

[4] Bulletin 3, Oil and Gas Resources, State Geological Survey.

[5] Leavenworth-Smithville Folio No. 206, U. S. Geological Survey, 1917.

stone in the south-central part of the county belong in this formation. They vary in thickness from a few inches to several feet and consist of a soft, yellowish-gray, yellowish-brown, or buff-colored, very fine grained sandstone containing considerable mica. The thickest outcrop was noted along Stranger Creek south of Big Stranger. This sandstone gives rise to the soils of the Boone and Bates series.

The lowest horizon in the Douglas formation is occupied by the Weston shale, which is a drab-colored, argillaceous shale with a distinct soap-like feel, and locally known as soapstone. This member is 55 to 100 feet thick. It is overlain by the Iatan limestone, 5 to 22 feet thick, which is light gray in color and contains large quantities of calcareous shells. Immediately above this is the Lawrence shale bed, 9 to 20 feet thick, and similar to the Weston shale, except that in places it has a reddish color and contains varying quantities of sandy shale. The top horizon of the Douglas formation, the Oread limestone, caps most of the hills in the vicinity of Leavenworth City and along the escarpment, and varies in thickness from 30 to 60 feet. This is the rock most commonly quarried for building material. It has a blue or bluish-gray color and weathers to a buff or gray. It contains considerable chert.

The highest formation underlying the county is the Shawnee. Its members are quite similar to the lower lying rocks, but are eroded considerably and in most places deeply covered by the more recent deposits of glacial till and loess. This formation underlies that part of the county above the Oread escarpment.

These alternating beds of limestone and shale contribute to the formation of the residual soils of the county, the Summit, Crawford, Bates, and Boone soils.

Overlying the residual material along the southern border of the county is a more recent deposit which is presumed to be of wind-blown origin. This deposit is composed of brownish-red to yellow-red clayey sand to sandy clay, which weathers to a buff or yellowish-brown color. It is porous and friable and apparently was laid down by southerly winds. This material lies in a belt from a few rods to a mile wide, north of the Kansas River bottom, and gives rise to the Derby series of soils.

The Kansan ice sheet, which covered most of the county after an extensive system of drainage had been developed in the formations described, left a deposit of bluish bowlder clay. This glaciation filled up some of the minor drainage ways, accentuated others, leveled off some of the less resistant elevations, and mixed the local material with varying quantities of débris brought from farther north. The action of the ice, inasmuch as its progress ended near the present valley of the Kansas River, was not as forceful and the drift deposit

not as thick as farther north. The deposit has been partly removed by erosion, and at present has an average depth in most places of less than 10 feet, and in many places is absent. The bowlder clay is deeply weathered and has oxidized to a reddish-brown or yellowish-brown color. The bowlders and rock fragments consist chiefly of Sioux quartzite, gneiss, granite, and greenstone, with locally acquired fragments of limestone, shale, and chert. It is supposed by some that the advance of the ice sheet was preceded by swift-flowing streams, which deposited small quantities of gravel and sand in pockets or beds.[6] This material may be Aftonian, and probably accounts for the ridges or pockets of gravelly material found in the south-central part of the county. The soil derived from these gravel deposits is mapped in the Shelby series. The soil derived from the Kansan material proper gives rise to the Shelby and Lindley soils.

Overlying the glacial débris in the northeastern part of the county was a fairly uniform deposit of wind-blown material, known as loess. This material is very fine grained, consisting chiefly of silt and clay, has a decidedly smooth or flourlike feel, and is free from coarse sand, gravel, or large rock fragments. The original material was brownish yellow or buff colored, and has been changed in surface appearance only by the darkening effect of the addition of organic matter. This loessial material has been washed away by recent erosion, until at present it rarely exceeds 30 or 40 feet in thickness at its greatest depth and may be entirely absent on the steeper slopes or rock outcrops. The average depth, except along the Missouri River, is probably less than 6 feet. The soils derived from this material in the upland are classed in the Muscatine, Grundy, Clinton, and Knox series.

The alluvial soils of the county may be subdivided into two groups with regard to topographic position, the terrace soils, lying above all probable overflow, and the first-bottom soils, those subject to overflow.

The terrace or second-bottom soils occur on nearly level, bench-like areas, lying from 2 to 10 feet above the first bottoms along the larger streams. The material from which they have been formed consists chiefly of loessial, glacial, and residual material washed down from the higher lying areas in the county and deposited on the flood plains of the streams when they flowed at higher levels. Owing to the similarity between this material and that found in the present flood plains it would seem that these terraces are not very old. The terrace soils of the county are classified in the Bremer, Chariton, and Waukesha series.

[6] Leavenworth-Smithville Folio No. 206. U. S. Geological Survey, 1917.

The first bottoms of the county have received material from both local and distant sources. The local material consists of wash from the loessial, glacial, and residual soils of the area and is dominantly dark colored and quite uniform in texture. The soils from this material are classed in the Wabash series. In the river bottoms the first-bottom material has been transported from areas farther up the streams and is less uniform in texture and lighter in color. Soil derived from this material is included in the Sarpy series. Low-lying material in these bottoms, which is subject to overflow at any slight rise in the streams and is materially changed at each inundation, is classed as Riverwash.

The various soils of the county are classed in series on the basis of color, origin, structure, and topography. The series are divided into soil units or types on the basis of texture, which is determined by the relative proportion of sand, silt, and clay in the surface soil. In Leavenworth County 11 soil series, represented by 19 soil types, are mapped in the upland; 3 series, represented by 5 soil types, on the terraces; and 2 series, with 9 types, on the first bottoms, in addition to Riverwash.

The soils of the Summit series are dark brown to black in the surface section and mottled yellow, brown, and gray in the subsoil. They are derived from the weathering of limestones and shales. The topography is undulating to gently rolling. The soils are distinguished from those of the Bates and Boone series, with which they are associated, in having darker colored soils and heavier subsoils. Two types and two phases are found in this county, the Summit silt loam and its heavy-subsoil phase, and the Summit clay loam and its colluvial phase.

The types of the Crawford series are characterized by dark-brown to reddish-brown surface soils and a reddish-brown to red subsoil. The soils are residual and derived from limestone and shale. The topography is undulating to rolling. Two types are mapped in this county, the Crawford stony loam and the Crawford silty clay loam.

The types of the Boone series are characterized by light-colored surface soils and a yellowish to grayish-yellow, porous or loose subsoil. Bedrock is encountered at shallow depths. The soils of this series are residual from sandstones and sandy shales. The topography is sloping to rolling. The series differs from the Bates, with which it is closely associated, chiefly in the smaller content of organic matter in the surface soil. Three types of the Boone series are mapped, the very fine sandy loam, loam, and silty clay loam.

The soils of the Bates series have dark grayish brown to dark-brown surface soils and a yellow to brownish-yellow subsoil. They are residual in origin, chiefly from sandstones and sandy shales.

The unweathered rock is encountered in places at shallow depths. The surface ranges from undulating to rolling. Only one type, the Bates loam, is mapped.

The Shelby series is characterized by dark-brown soils, a brownish-red upper subsoil, and a brownish-red, loose, gravelly lower subsoil. The upper soil section usually contains considerable glacial gravel and sand. The series is derived from glacial material. The topography varies from knolly to rolling. Two types and one phase are mapped in this area, the loam, with a gravelly-subsoil phase, and the silt loam.

The Lindley soils are light brown to grayish brown or brownish gray in the surface soil. The subsoils are mottled yellowish brown, reddish brown, and grayish brown, rather compact in the upper portion and more friable in the lower. The entire soil section contains considerable glacial grit. These soils are derived from glacial material, and differ from the Shelby soils chiefly in the lighter color of the surface soil. The topography is rolling. Two types occur in this county, the Lindley loam and Lindley silt loam.

The types of the Muscatine series are characterized by dark-brown surface soils, a rather compact brownish-yellow upper subsoil, and a friable, mottled buff and gray, lower subsoil. The Muscatine silt loam, the only type of this series developed in the county, has a smooth, rather even texture and is free from pebbles or rock fragments. This soil is formed from the shallow deposits of Missouri loess, and most of the soluble lime has been leached below the 36-inch depth. The topography is rolling.

The Grundy series consists of types with dark-brown to black surface soils and a compact, mottled drab and brownish-yellow, heavy subsoil. The soils are derived from the silty material of the shallow deposits of Missouri loess. The topography is flat to gently undulating. The soils differ from the Muscatine in their deeper surface soils and more compact subsoil. One type, the Grundy silt loam, is found in this county.

The soils of the Clinton series are characterized by brownish-gray to grayish-brown or buff-colored surface soils, and a mottled brownish-yellow and gray subsoil, which is compact in the upper part and more friable in the lower. These soils are derived from deposits of loess, and they differ from the Muscatine soils chiefly in the lower content of organic matter in the surface soil. Two types are mapped in this county, the Clinton silt loam and Clinton silty clay loam.

The Knox series consists of types with brownish-yellow to yellowish-brown surface soils and a yellowish-brown or buff-colored subsoil. The entire soil section is smooth, silty, and quite uniform in texture. The surface is rolling to strongly rolling. The series

differs from the Clinton chiefly in the absence of a compact upper subsoil. One type and a phase are mapped, the Knox silt loam and its steeply rolling phase.

The surface soils of the Derby series are brownish gray to grayish brown, and the subsoil is yellowish red to reddish yellow and friable. These soils are probably wind-blown in origin and derived chiefly from residual prairie material. The surface is sloping to rolling. The series in this area is lighter in color and less calcareous than in the areas farther west. The darker color of the soils farther west is due to a larger accumulation of organic matter. The Derby series is represented in this county by the fine sandy loam and the loam.

The Bremer series comprises soils that are dark brown to black in the surface section and dark grayish brown to dark brownish gray in the subsoil. The subsoil is as heavy as the surface soil, or heavier, to a depth of three feet or more. The series is confined to terrace plains, and differs from the Wabash series in its positions above overflow. Two types of the Bremer series are mapped, the silt loam and the silty clay loam.

The types of the Chariton series are similar to those of the Bremer in origin and position. They have dark-gray to dark-brown surface soils. The subsoil has a layer of ashy-gray silty material in the upper part, resting upon a black to dark-drab, rather compact clay. Drainage is fairly good to poor. One type, the silt loam, is mapped.

The Waukesha series differs from the Bremer chiefly in the color of the subsoil, which is brown to yellowish brown. The soils are derived chiefly from loessial material. They occupy terraces and are well drained. The Waukesha series is represented in this county by the very fine sandy loam and the silt loam.

The Wabash series includes types with dark-brown to black surface soils and a dark brownish gray, heavy subsoil. The material is derived chiefly from the fine-textured soils of the uplands of the county. The series occurs in first bottoms, and the drainage is fair to poor. Four types are mapped in the area, the loam, silt loam, silty clay loam, and clay.

The Sarpy series includes brownish-gray to grayish-brown soils, with a subsoil that is lighter in texture in the lower part, and frequently passes into loose sand within the 3-foot section. Both soil and subsoil are calcareous. The surface soils are somewhat deficient in organic matter. The soils of this series occupy first bottoms subject to overflow. The fine sand, fine sandy loam, very fine sandy loam, loam, and clay occur in this area.

Riverwash includes small areas of nonagricultural, coarse-textured soil along the channels of the Missouri and Kansas Rivers, where the material is shifted and altered at each rise of the stream.

The various soils encountered in Leavenworth County are described in detail in the following pages of this report and their relation to agriculture discussed. Their distribution is shown on the accompanying soil map, and their actual and relative extent are given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Summit silt loam	52,416	21.1	Sarpy clay	3,264	1.1
Heavy-subsoil phase	9,728		Wabash loam	3,072	1.1
Shelby loam	51,584	17.8	Derby fine sandy loam	2,624	.9
Gravelly-subsoil phase	1,024		Chariton silt loam	2,624	.9
Clinton silt loam	20,480	7.0	Clinton silty clay loam	2,368	.8
Shelby silt loam	19,840	6.7	Sarpy loam	1,984	.7
Muscatine silt loam	18,432	6.3	Riverwash	1,600	.5
Wabash silt loam	17,344	5.9	Wabash clay	1,408	.5
Bates loam	14,336	4.9	Bremer silty clay loam	1,152	.4
Summit clay loam	1,920	4.0	Sarpy fine sand	1,024	.3
Colluvial phase	9,792		Lindley silt loam	960	.3
Crawford silty clay loam	9,728	3.3	Boone very fine sandy loam	896	.3
Boone loam	8,320	2.8	Grundy silt loam	768	.3
Crawford stony loam	7,424	2.5	Sarpy fine sandy loam	768	.3
Sarpy very fine sandy loam	5,056	1.7	Knox silt loam	384	.2
Wabash silty clay loam	4,736	1.6	Steeply-rolling phase	256	
Boone silty clay loam	4,672	1.6	Waukesha very fine sandy loam	256	.1
Lindley loam	4,480	1.5	Waukesha silt loam	256	.1
Derby loam	3,968	1.3			
Bremer silt loam	3,456	1.2	Total	294,400	.....

SUMMIT SILT LOAM.

The surface soil of the typical Summit silt loam is a very dark brown, moderately heavy silt loam, from 12 to 15 inches deep. This is underlain by a rather compact, mottled dark-brown or dark yellowish brown and dark-drab, silty clay loam. At about 20 inches the subsoil changes to a mottled yellow, brown, and gray, moderately friable, silty clay loam, which becomes more friable with depth. The organic content of the surface soil is high. The compact nature and dark color of the subsurface layer is probably due to a concentration of clay particles and organic matter leached down from the surface soil. This layer may be dark brown or dark yellowish brown in places, especially where close to the loessial soils. Dark-brown to black iron concretions and stains are numerous in the lower subsoil. Particles of glacial grit or limestone fragments may occur in the upper soil section, where the soil has been influenced by glacial action.

The soil is less uniform in the smaller areas, in places the subsoil may be more compact, and in all of the areas spots occur in which

the structure resembles that of the heavy-subsoil phase. A bed of limestone or shale may underlie the soil at 4 to 6 feet in the more rolling areas, and in a few places the lower subsoil is a yellowish-gray, "soapy," silty clay resembling the unweathered parent shale. On a few of the eroded slopes the upper subsoil has mottlings of reddish brown, and the surface soil is shallower. In the extreme southern part of the county a few areas have a small quantity of fine sand and very fine sand deposited on the surface by wind action. In areas in the northeastern part of the county the surface soil may have an admixture of loessial material, causing it to resemble that of the Muscatine silt loam.

This soil was formed by the weathering of the underlying limestones and shales. When a good organic content is maintained it is easy to cultivate, and when tilled under ordinary moisture conditions it granulates or breaks up into small particles and does not bake or crack badly. It was originally covered with a luxuriant growth of prairie grasses, chiefly bluestem and grama grass.

The Summit silt loam occupies areas in all parts of the county except the loessial section north and northwest of Leavenworth City. Most of it is in rather large bodies below the Oread escarpment, where it commonly covers the divides. A few good-sized areas, however, lie immediately above the escarpment in the central and western parts of the county and in the northwest corner. The general topography of the region in which this soil occurs is undulating to gently rolling or rolling, and the Summit silt loam occupies the undulating or gently rolling divides and the gentle slopes. That part of the type below the escarpment in the vicinity of Jarbalo and Tonganoxie occupies a topographic position resembling a very old, preglacial terrace, and the surface is undulating. Farm tractors and all modern machinery can be used to advantage on practically all the type.

The drainage is good, though it may be rather slow in isolated areas along small, sluggish streams or along such streams in the larger bodies. The drainage, however, has been greatly improved in comparatively recent years by the cutting of the drainage ways to greater depth. Faint traces of lighter colored subsurface material are found here and there, indicating that drainage must have been obstructed at some earlier time. The surface run-off over most of the type is through broad V-shaped, intermittent drainage ways. The soil is quite retentive of moisture and crops rarely suffer from drought.

The Summit silt loam is the most extensive upland soil in the county and one of the most desirable soils for general farming. It includes very little waste land, and practically all of it is under

cultivation. The most important crops are corn, wheat, oats, and hay. Wheat is the cash crop. Cultivated grasses are being grown more extensively each year in systematic rotations and used in the feeding of live stock. Red clover is the most popular legume, though alfalfa occupies nearly as large an acreage. Many small farm orchards are located on the type and a few commercial orchards, but the trees do not do as well as on the loessial soils. However, much larger yields could be obtained if more attention were given to pruning and spraying the trees, as demonstrated in the large commercial orchard north of Fairmount. The main live-stock industries are dairying and the raising of hogs. Dairying is carried on either as the main industry or in conjunction with general farming.

Ordinarily corn on this soil averages from 20 to 30 bushels per acre.[7] In very favorable years a yield of 50 to 70 bushels per acre is not uncommon. The average yield of wheat is 16 to 20 bushels per acre, and of oats 35 to 45 bushels. Some barley is grown to supplement corn for feeding hogs, the yield being about the same as for wheat. Red clover usually produces 1½ to 2 tons of hay per acre; timothy, 1 to 1½ tons, and alfalfa, 2 to 3 tons. Grain sorghums yield well, but are not as commonly grown as on the heavy-subsoil phase.

By following the methods of handling as practiced by the more progressive farmers, the productiveness of this soil can be easily maintained. Most of the farmers recognize the value of crop rotation, and many follow a definite system with excellent results. The most common rotation consists of corn one year, oats one year, wheat one year and clover two years, after which the land is returned to corn. Timothy is often sown with the wheat in the fall and red clover added the following spring. Farmers growing two crops of corn in succession report that the first crop following clover yields several bushels more per acre than the second crop. Alfalfa when established does well, and a stand can usually be obtained if the seed bed is carefully prepared and the seed or the ground inoculated.

Commercial fertilizers are not used to any extent on this soil at present, but from the results obtained by a few farmers it would seem that a fertilizer containing phosphoric acid could be used profitably. The best farmers keep enough live stock to consume practically all the corn, oats, and hay produced. These farmers usually apply the manure saved to the small-grain land.

The farms on this type are, in general, fairly well improved. Water usually can be obtained at depths ranging from 25 to 60 feet. Most of the farms range in price from $125 to $200 an acre. The difference in value depends largely upon the improvements and location with regard to a market or improved road.

[7] Statements of yields, in this report, are based on information obtained from farmers.

The Summit silt loam can best be improved by the application of barnyard manure, or the growing and plowing under of a legume crop. A part of the efficacy of such treatment lies in increasing the water-holding capacity of the soil.

Summit silt loam, heavy-subsoil phase.—The heavy-subsoil phase of the Summit silt loam differs from the typical soil chiefly in having a heavy, compact subsoil. It consists usually of a dark brown surface soil about 12 inches deep, underlain by a tough, compact claypan or silty clay which is mottled yellow, gray, and brown or reddish brown. The lower subsoil in places contains small brown iron concretions and stains.

This phase is quite variable in depth of soil, content of organic matter, and color of subsoil, but the nearly impervious structure of the subsoil is quite consistent. The subsoil may be brownish red in the upper section in very small areas. Along the Wyandotte County line and Wolf Creek the surface soil is brown in color and a heavy silt loam in texture. The subsoil is a compact silty clay, brown to yellowish brown in the upper part and mottled yellowish brown and gray in the lower. In the vicinity of areas of glacial soils the surface soil may contain a small amount of pebbles. On some of the lower slopes, where the fall is slight and the drainage may have been poor in more remote times, the surface soil is grayish brown to dark grayish brown in color, and the subsoil is a mottled drab and brown or yellowish-brown, nearly impervious silty clay. In places small fragments of clayey or sandy shale occur in the subsoil. In areas close to the Kansas River the surface soil contains here and there small quantities of wind-blown sand.

Several small gravelly areas of the phase to the south and southeast of Reno, indicated on the map by gravel symbols, differ from the rest of the phase in that the soil section contains large quantities of chert fragments and an occasional admixture of glacial gravel. The color of the surface soil in these areas varies from dark brown to brown, and of the upper subsoil from reddish brown to mottled yellow, reddish brown, and gray. The lower subsoil is usually a mottled yellow and gray or drab, "soapy," silty clay loam, not unlike the underlying clayey shales. These areas usually occupy small ridges or knolls and were probably influenced considerably by glacial action.

Most of the heavy-subsoil phase of the Summit silt loam occurs below the Oread escarpment to the south of the Kansas City Northwestern Railroad, though a few areas lie north of this road, one area south of Jarbalo being of good size. The topography of the phase is much the same as that of the typical soil, though the areas in most places have a lower position. Exceptions occur south of Reno, where the phase covers some of the rather narrow divides. The surface

drainage is good, but the underdrainage is obstructed by the heavy subsoil.

The phase is residual in origin and has undoubtedly been formed from the limestone and shales of the region, but it is probable that it was influenced by some parent material differing from that of the typical Summit silt loam.

The heavy-subsoil phase of the Summit silt loam originally supported a growth of prairies grass, and much of it has never been put under cultivation. The phase supports some of the largest pastures for cattle, horses, and sheep in the county. It is a good soil for grass and is nearly everywhere covered with a heavy sod. Prairie grass cut from it averages about 1¼ tons of hay per acre.

On the cultivated parts, the most important crops are wheat, oats, hay, corn, and grain sorghums. Wheat ordinarily yields 12 to 18 bushels per acre, and oats, 25 to 30 bushels. The corn yield is often seriously reduced in the drier seasons and probably averages from 12 to 18 bushels per acre. Corn is often displaced or supplemented by kafir, which yields well in the average year. The main hay crop is timothy and red clover, with some millet, and the yields are ordinarily good. Sudan grass has been grown in recent years with good results.

The heavy-subsoil phase of the Summit silt loam has a lower average range in price than the typical soil.

The productiveness of this soil could be increased by the addition of organic matter, and by the adoption of a systematic rotation of crops. Any system of rotation should include a green-manure crop to be turned under. Possibly corn should be displaced to a large extent by a grain sorghum. Many farmers at present are planting the phase to grass crops, both for pasturage and for hay, and are utilizing it chiefly for stock raising. This is probably one of the best uses to which much of this soil can be put.

SUMMIT CLAY LOAM.

The Summit clay loam, to a depth of about 15 inches, is a dark-brown to black silty clay loam or clay loam, gradually grading downward into a silty clay. This is underlain by a mottled dark-brown and dark-drab, rather compact silty clay. At 22 inches the subsoil grades into a mottled drab, yellow, and brown, or mottled yellowish-drab and yellowish-brown silty clay or heavy silty clay loam, containing a few small lime concretions. The surface soil is high in organic matter, and in places reaches a depth of 18 or 20 inches. The subsoil contains reddish-brown or black iron stains here and there in the lower depths.

The Summit clay loam is mainly of residual origin but in all probability has received a shallow surface deposit as wash from the adjacent limestone and shale hills.

Most of this soil occurs as long, narrow bodies at the base of the Oread escarpment, from Jarbalo southwest. Other small areas lie near Basehor within bodies of the Summit silt loam. The surface of the type is flat to nearly level, and the natural drainage is rather poor. Much of it receives seepage water from the adjacent hills during the early part of the growing season, and unless drained it warms late in the spring.

The Summit clay loam is very productive when properly drained and carefully managed. When wet it is very sticky, and upon drying it cracks badly, though its high organic content tends to prevent excessive cracking.

Most of the soil is under cultivation, though some still remains in the native sod and supports a luxuriant growth of grass, which is generally cut for hay.

The most important crops grown on the type are corn, alfalfa, wheat, oats, and clover. Where the type is properly drained with tile, as in many of the areas south of Tonganoxie, the yields from these crops are as high as on any soil in the county. In these drained fields corn ordinarily yields about 45 bushels per acre; wheat, 14 to 18 bushels; oats, 20 to 30 bushels; alfalfa, from 3½ to 4½ tons; and clover, about 2 tons. Because of the marked fertility of the soil small grains have a tendency to grow too rank and lodge in wet seasons.

The Summit clay loam is handled much the same as the associated type, the Summit silt loam, though heavier draft power is required in tillage operations. Little barnyard manure is applied. Several farmers report that the cost of tile drainage is repaid within a few years after installation.

This soil sells for as high a price as the Summit silt loam, if properly drained. Alfalfa land on this type ordinarily rents for $25 an acre.

Summit clay loam, colluvial phase.—The colluvial phase of the Summit clay loam differs from the typical soil chiefly in its topographic position and better drainage. It occurs as very narrow strips on the foot slopes below the outcrops of limestone and shale which are exposed in all parts of the county where the Oread escarpment is prominent, and in the southwestern part. These strips average less than one-eighth mile in width, though a few are as wide as three-eighths mile. The slope is very rarely too steep for cultivation.

The soil was formed of material weathered from the exposed limestones and shales and carried down the slope to its present position by gravity. The surface soil is a nearly black silty clay loam or clay loam in the surface 6 inches, underlain by a nearly black clay loam to silty clay. The subsoil, beginning at 8 to 20 inches, depend-

ing upon the position on the slope, is a rather compact, mottled gray, yellow, and brown, or yellow and gray clay loam, which commonly grades into a grayish-yellow or yellowish-gray, "soapy" silty clay within the 3-foot section. The surface soil is thinnest near the upper margin of the areas and deepest at the lower. On the wider areas the underlying "soapy" material is seldom encountered within the 3-foot section, except near the upper margin. This material is highly micaceous, porous, and fairly retentive of moisture. Small rock fragments may be found throughout the soil section, but rarely in quantities large enough to interfere with cultivation.

While the drainage of the phase is normally good, small spots occur where the fall is slight, in which seepage water interferes with early cultivation. This is remedied in most cases by laying tile drains. A few farmers use open ditches in reclaiming such areas, but much trouble is experienced in keeping them open, on account of the readiness with which the higher lying material erodes.

The colluvial phase of the Summit clay loam, though occurring in very narrow areas, is practically all under cultivation. It originally supported a heavy growth of trees common to the region. In many places even exceedingly narrow areas of the type are cleared and put under cultivation, while the remainder of the slope is left with its forest growth. The phase is usually very productive. It is devoted to practically the same crops and gives about the same yields as the typical Summit clay loam. Probably a larger proportion of the phase, however, is devoted to corn.

The following table gives the results of mechanical analyses of samples of the soil, subsurface, and subsoil of the typical Summit clay loam:

Mechanical analyses of Summit clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381606	Soil	0.2	1.1	0.7	4.2	11.0	58.0	24.8
381607	Subsurface	.2	1.1	1.0	8.7	11.2	50.2	27.3
381608	Subsoil	.2	4.5	3.7	6.0	2.8	55.6	27.3

CRAWFORD STONY LOAM.

The Crawford stony loam comprises those areas of land too stony or rocky to permit profitable cultivation. It includes all the limestone outcrops large enough to be shown on a map of the scale used. Along some of the low-gradient streams or more gentle slopes there are small patches of soil which support a good growth of grass and are utilized for pasture. The color of this soil is prevailingly red

or brownish red, although in some of the areas it is dark brown to black, underlain by a yellowish-gray "soapy" clay, much like that of the colluvial phase of the Summit clay loam. The soil material ranges from a silt loam, silty clay loam, or clay loam above the Oread escarpment to a loam or sandy loam along the Kansas River. It is rarely over 12 or 15 inches deep.

The type occurs as very narrow, irregularly shaped strips. It is found along the main line of the Oread escarpment, along the more deeply cut streams north and west of that escarpment, and along the high-gradient streams in the southeastern part of the county. The difference in elevation of the upper and lower margins of the type ranges from 40 to 180 feet.

The type is valuable only for pasture and for its forest growth, which consists chiefly of oak, elm, hackberry, hickory, and black walnut.

CRAWFORD SILTY CLAY LOAM.

The surface soil of the Crawford silty clay loam is quite variable in depth. Generally it is a dark reddish brown to reddish-brown, or at times a brown silty clay loam about 6 inches deep. The subsoil is a brownish-red, rather friable silty clay loam, uniform in color and structure down to the basal limestone, which is usually encountered at depths of 2 or 4 feet. In the loessial region of the county the surface layer, a few inches thick, consists of a buff-colored silt loam or silty clay loam. In areas adjacent to glacial soils the upper soil section may contain glacial gravel, and in the southern part of the county the soil may contain small fragments of chert. The subsoil in the narrower areas contains dark-brown iron stains and is slightly mottled with reddish brown and yellowish brown in the upper part. This variation, however, is not extensive.

The Crawford silty clay loam occurs in all parts of the county where the basal ledges of limestone are exposed. Most of it is above the Oread escarpment and along Wolf Creek. It usually occurs immediately above the outcrop as very narrow, irregularly shaped strips rarely as much as one-eighth mile in width. It may occupy the whole of very narrow divides, or occur in a position between the other high-lying soils and the break above the escarpment. It is formed directly from the weathering of limestones and shales. Much of it in the loessial region has been entirely covered by the silty wind-blown deposit. The surface is undulating to gently sloping, and the drainage is good.

This soil supported originally a vegetation consisting chiefly of prairie grass. Much of it is still in the native sod and is used for pasture. Most of it, however, is under cultivation with the adjoining soils. It is handled the same as those soils and is devoted to the

same crops. Corn ordinarily yields about 18 bushels per acre; wheat, 16 to 18 bushels; and oats, 25 to 35 bushels. Where the soil is shallow above the bedrock the crop suffers in the drier years.

Land of the Crawford silty clay loam usually sells for the same price as the adjacent soils with which it is farmed.

This soil is greatly benefited by the liberal application of barnyard manure or the turning under of green-manure crops.

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

Mechanical analyses of Crawford silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381663	Soil	0.4	0.9	1.2	7.0	9.4	50.0	31.5
381664	Subsoil	.4	1.5	2.3	12.9	6.5	38.5	38.3

BOONE VERY FINE SANDY LOAM.

The surface soil of the Boone very fine sandy loam consists of a brownish-gray to grayish-brown very fine sandy loam, of varying depth, but with an average depth of about 12 inches. The subsoil is a grayish-yellow or pale-yellow to bright-yellow very fine sandy loam to loamy very fine sand, which grades beneath into a soft, light yellowish-gray, very fine grained sandstone. The surface soil is deficient in organic matter. The substratum of soft sandstone may occur near the 3-foot depth or may be exposed on the steeper slopes. In places small fragments of sandstone in various stages of disintegration are found scattered throughout the upper soil section. The lower subsoil is normally highly micaceous.

In a few of the areas in the southeastern part of the county, as northeast of Linwood, a part of the basal sandstone, from which this soil is derived, is brownish red to reddish brown. This darker colored rock may occur above the yellowish-gray sandstone, as pockets within a stratum, or mixed with it in no definite position. Where much of this red sandstone occurs, the resulting soil is brown to reddish brown in the surface section, and brownish red in the subsurface.

The areas of Boone very fine sandy loam are small and widely scattered over that part of the southern half of the county that lies below the Oread escarpment. It commonly only occurs on slopes, either along the larger creeks or near the heads of intermittent drainage ways. Erosion is active in many of the areas, especially where the slopes are steep, and has cut numerous small gullies or ravines into the soft bedrock.

Very little of this soil is under cultivation, as it is only moderately productive. It is an early soil, but the entire soil section dries out quickly, and in very dry seasons the type is droughty. The more rolling areas are used for pasture. These support a rather scant growth of prairie grass. Some timber grows on those areas near the larger streams. Some of the flatter areas are included in fields with other soils and have been brought up to a good state of productiveness through the application of liberal quantities of barnyard manure. On these areas a grain sorghum is the crop most commonly grown, and good yields are obtained. Corn also gives good yields in favorable years.

This soil is usually included in farms with associated types, and a separate value can not be definitely stated.

Below are given the results of mechanical analyses of samples of the soil, subsurface, and subsoil of the Boone very fine sandy loam:

Mechanical analyses of Boone very fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381637	Soil	0.3	0.4	0.3	22.0	48.1	17.5	11.2
381638	Subsurface	.0	.0	.4	18.8	55.2	8.9	16.8
381639	Subsoil	.0	1.8	2.2	22.4	65.4	6.7	1.5

BOONE LOAM.

The surface soil of the Boone loam, to a depth of 10 or 12 inches, is a grayish-brown or brownish-gray (when dry) loam, relatively high in silt and very fine sand. This is underlain by a pale-yellow to grayish-yellow heavy loam, with a high percentage of very fine sand. At depths varying from 27 to 36 inches, a stratum of yellowish-gray sandstone or sandy shale is encountered. The surface soil is low in organic matter. The subsoil contains numerous small flakes of mica.

The surface soil is lighter colored on the more rolling areas and darker on the flatter parts of the type or near the base of gentle slopes. On many of the steeper slopes the underlying sandy shale or sandstone is exposed. In the southeastern part of the county the yellowish-gray sandstone is in places covered by or mixed with a yellowish-brown to reddish-brown sandstone. This gives a yellowish-brown color to the lower subsoil. In parts of this type lying adjacent to heavier textured upland soils the upper subsoil is a light silty clay loam, mottled yellowish brown and reddish brown, and grades downward into a pale-yellow very fine sandy loam or very fine sand. In areas in the northwestern part of the county the surface

soil in places contains fragments of rock which have washed down from higher lying glacial soils, and the subsoil usually contains fragments of sandy or of clayey shale. In the loessial region, especially south of Lansing, the surface soil contains an admixture of buff-colored silty material.

The type is derived mainly from very fine grained, micaceous, gray or yellowish-gray, soft sandstone occurring in the beds of sandy shale and limestone of the Douglas formation.

The Boone loam occurs chiefly as small areas in that part of the county below the Oread escarpment and south of Leavenworth City. The largest areas lie east and southeast of Tonganoxie. The type has a gently rolling to rolling topography. Surface drainage is good and on some of the steeper slopes the run-off is rapid with resulting deep gullies or ravines. The underdrainage is inclined to be excessive over most of the type on account of the porous and rather open character of the subsoil.

This soil, though rather extensive, is relatively unimportant in the agriculture of the county. Probably half of it remains in the native prairie grass and is used chiefly for pasture. The grass growth is fairly good, and where cut averages three-fourths ton of hay per acre.

On cultivated land the most important crops are wheat, oats, hay, corn, and grain sorghums. Wheat has been grown continuously on a few fields of this soil for 20 years or more. Probably less corn and more grain sorghum is grown in proportion to the small grains than on any other soil in the county. Very little alfalfa is grown. In sowing alfalfa better success is obtained with fall seeding than spring seeding. This probably is a matter of moisture conditions. Inoculation is usually necessary to obtain the best results.

Crop yields on the Boone loam vary somewhat with the proportion of organic matter in the surface soil and with the depth at which the substratum of sandstone occurs. Wheat ordinarily yields 10 to 14 bushels per acre, and oats 20 to 25 bushels. The corn yields are good in favorable seasons, but in very dry years they are somewhat lower, especially on fields where the sandstone occurs at shallow depths. Kafir is the most popular grain sorghum and produces a good average yield. It is displacing corn on many farms, especially when indications point toward a growing season of scant rainfall. Clover yields about 1¼ tons of hay per acre in the average year, and timothy about 1 ton. Sudan grass does well.

This soil is easy to cultivate and maintain in good tilth throughout the year. It warms up quickly in the spring and can be planted and cultivated early, but it is normally low in organic matter and dries out quickly. Crop rotation is practiced very little on this type.

The State experiment station, in cooperation with farmers, has carried on experiments in the use of commercial fertilizers on this soil east of Tonganoxie and north of Linwood. The results indicate that as much as 180 pounds per acre of bone meal can be used with profit on land to be seeded to wheat, oats, or clover, but that the greatest return is usually obtained from the use of 100 to 120 pounds.[8] Other experiments in eastern Kansas indicate that an application of commercial fertilizer is frequently the deciding factor in obtaining a stand of grass, and that it can often be used with profit at the time of seeding alfalfa. On the other hand, these experiments show that commercial fertilizers are not as satisfactory for this purpose as barnyard manure. The best results were obtained from the use of a commercial fertilizer containing phosphoric acid, as most of the residual soils in this part of the State are deficient in that element.

During recent years several farmers have been applying steamed or raw bone meal to fields of this type to be planted to wheat, at the rate of 75 to 125 pounds per acre. They report that wheat yields from 5 to 10 bushels more per acre on land so treated, and that the following corn crop is less likely to suffer if the season is droughty. Wheat is the only crop for which commercial fertilizers are commonly used.

Land of the Boone loam ordinarily sells for $70 to $125 an acre, depending upon the location, condition of the land, and improvements.

The productiveness of this soil can be materially increased by the liberal use of barnyard manure, by green manuring, and by following a system of rotation including a legume. Excessive washing on the steeper slopes can be prevented by keeping these slopes in cover crops.

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

Mechanical analyses of Boone loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381640	Soil	0.0	0.8	0.2	1.4	36.4	49.1	12.1
381641	Subsoil	.0	1.8	.4	1.1	21.6	53.9	21.3

BOONE SILTY CLAY LOAM.

The surface soil of the Boone silty clay loam is variable. Prevailingly it is a brownish-yellow silty clay loam and very shallow. On

[8] Bul. 220, Kans. Agr. Expt. Sta., Soil Fertility.

the lower margins of the type it may contain considerable organic matter and be brown to dark yellowish brown in color. On some of the slopes that lie below glacial material, fragments of that material may be washed down and intermixed with the surface soil. Likewise, in areas in the loessial region, there may be a small amount of silty material mixed with the surface soil. The subsoil is typically a pale-yellow or grayish-yellow to yellow, "soapy" silty clay, which is composed chiefly of clayey shale in various stages of disintegration. In a few places where the parent material is in an advanced stage of weathering, the upper subsoil is a yellowish-brown silty clay loam. In the areas in the northwestern part of the county small fragments of sandy shale occur in places throughout the soil section.

The Boone silty clay loam is derived from underlying shale and limestone formations. It usually occurs on slopes where beds of these rocks are exposed; consequently most of it is in long, narrow, irregularly shaped strips along the escarpment lines in the northern and western parts of the county. Very little of it occurs on the lower levels below the Oread escarpment. Narrow limestone outcrops are not uncommon.

This soil is very low in organic matter and dries out quickly. Most of it is subject to destructive erosion, and on the upper margins of the areas the raw basal shales are exposed. Where organic matter has accumulated the soil is moderately productive, but most of the type has a rather low agricultural value. Very little of it is under cultivation, and where tilled it is usually farmed in fields with the adjacent soils. The greater part of it has a scant growth of bunch grass and scrub trees and is utilized as pasture for cattle and sheep. Over most of the type it is difficult to use modern farm machinery because of the rather steep slopes, and much of the type is best adapted to grazing. Orchard grass, bluegrass, and alsike clover do well, and all sorghums are successfully grown on the better fields.

An increase in the productiveness of this soil can be brought about by the extensive use of barnyard manure and by turning under green-manure crops.

Below are given the results of mechanical analyses of samples of the soil and subsoil of the Boone silty clay loam:

Mechanical analyses of Boone silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381648	Soil	0.5	1.5	1.2	6.6	16.1	40.7	33.5
381649	Subsoil	.2	1.6	1.0	4.1	4.5	40.4	48.3

BATES LOAM.

The Bates loam differs from the Boone loam chiefly in having a deeper and darker colored surface soil. The surface soil is a dark grayish brown to dark-brown, mellow loam, about 12 inches deep. The subsoil is a brownish-yellow to yellowish-brown, friable, light silty clay loam, which gradually becomes sandier in the lower part of the 3-foot section and rests on a bed of soft sandstone. This sandstone is similar to that underlying the Boone loam, and most of it is yellowish gray to gray in color. There are, however, several areas north of Linwood where much of the basal sandstone is brownish red to red. In these areas the surface soil is usually brown to reddish brown in color, and the subsoil is brownish red. Small fragments of partly disintegrated sandstone or sandy shale are found here and there in the upper part of the soil section and on the surface. Shallow outcrops of the basal sandstone, from which the soil is derived, are common on some of the steeper slopes.

In some of the flatter areas, adjacent to areas of the Summit soils, the upper subsoil is rather compact and mottled reddish brown and yellowish brown. Occasional small spots occur, in which a hardpan has developed as in the Shelby loam. Small strips of Boone loam, too small to show on the map, are included in this type, especially on the steeper slopes.

The Bates loam occurs in gently rolling to rolling upland areas scattered over the southern part of the county. Practically all of it lies below the Oread escarpment. The largest areas of the type are mapped near Linwood and south of Glenwood School. The type usually lies in a somewhat lower position than the darker upland soils, and when occurring on slopes below the glacial soils it may have a thin surface deposit of glacial material. It occupies a few narrow divides. The type is well drained, and in some of the more rolling areas the surface is subject to destructive erosion.

This type originally supported a growth of prairie grass on the flatter areas and forest on the more rolling areas. Much of it remains in the native growth and is used for pasture. Probably over half of it is under cultivation. In productiveness it ranks between the Boone loam and the darker colored glacial soils. On the best fields it produces good average yields, but where the soil is thin or the surface more rolling than typical, it is somewhat droughty in dry seasons. It is an early soil, and is easy to cultivate and keep in good tilth.

The Bates loam is devoted to practically the same crops as the Shelby loam. Sorghums are relatively important for forage and grain. Sudan grass has been grown by some farmers with good results. Dairying and raising beef cattle are the principal livestock industries, though hogs are kept in small herds by most farmers.

Dairying is practiced in conjunction with general farming, and the milk or cream is sold to the local buying stations.

Over the type as a whole corn yields 14 to 19 bushels per acre in the average year; kafir, 15 to 20 bushels; wheat, 11 to 15 bushels; and oats, 20 to 30 bushels. Much higher yields are obtained in favorable years and on the better lying land. Native hay yields 1 ton or more per acre; sorghum, 2 to 4 tons; Sudan grass, about 3 tons; and clover, 1 to 1½ tons.

This soil is handled much the same as the Shelby loam. Commercial fertilizers have given good returns when used on wheat. The methods suggested for the improvement of the Boone loam should prove equally beneficial to this soil.

Land of the Bates loam generally sells for $85 to $125 an acre, depending upon the location and the condition of the soil.

SHELBY LOAM.

The surface soil of the Shelby loam consists of a dark-brown mellow loam, which grades at about 10 inches into a grayish-brown heavy loam to light silty clay loam. The subsoil, lying at 12 to 15 inches, is a mottled yellowish-brown and reddish-brown, rather compact clay loam, which grades gradually at about 27 inches into a yellowish-brown, gritty, friable clay loam or heavy silty clay loam, commonly with gray to grayish-yellow mottlings. The surface soil has not as much organic matter as that of the associated Shelby silt loam. The subsoil in places contains brown or blackish-brown iron stains in the lower part, and here and there a few lime concretions. Most of the type, however, is not strongly calcareous, according to tests with hydrochloric acid. The entire soil section contains varying quantities of glacial gravel and coarse sand, and a few large glacial bowlders appear on the surface. In no place, however, does the presence of glacial gravel or bowlders interfere seriously with cultivation or make the soil materially less retentive of moisture. The surface soil is lighter colored and contains less organic matter near areas of the Derby soils.

In places the subsoil is a yellowish-brown, rather compact clay loam in the upper part, and a yellow-brown, friable silty clay loam mottled with grayish brown or gray in the lower part. In a few other places, particularly near the areas of Shelby silt loam, the subsoil is a yellowish-brown, moderately friable silty clay loam throughout, with gray mottlings in the lower parts only. Where the surface soil has been washed away, as is the case in many cultivated fields on the steeper slopes, the resulting soil is a brown, heavy loam to light silty clay loam, and is harder to handle than the typical soil. These spots are of very small extent. Where the soil is very thin it is likely to crack rather badly in dry seasons. In the vicinity

of areas of the Shelby loam, gravelly-subsoil phase, and on a few of the narrow hillcrests south of Reno and near Jarbalo, the subsoil is a reddish-brown silty clay loam, rather compact in the upper part and more friable in the lower. In these areas the surface soil in places has a dark reddish brown to brown color.

In all parts of the county there occur small scattered spots that have at some previous time been affected by alkali salts. These spots may occur in any topographic position and are not confined to the Shelby loam, but occur in practically all of the glacial and residual soils in the county. They are, however, more numerous in the type mentioned. The spots, which seldom have a diameter of more than 100 feet, contain a claypan or hardpanlike material, which is mottled reddish brown and yellowish brown and in places grayish brown. The land in these areas is very unproductive and hard to handle. The farmers state that by making heavy applications of manure before plowing a fairly good yield of small grain can be obtained, but that it is necessary to repeat the applications year after year to keep the soil productive.

The Shelby loam is of glacial origin, but it is likely that in parts of the county the glacial material has been modified to some extent by the admixture of residual material. The glacial drift in this county is in most places very thin, and on some of the sharper slopes in the southwestern part of the county fragments of sandy shale are found in the surface soil, or the bedrock may be encountered at depths not greater than 4 feet.

The Shelby loam areas occur in all parts of the county. The largest continuous areas lie above the Oread escarpment on both sides of Stranger Creek, near Boling, and in the southeastern corner of the county. In the large areas the type occupies the divides and slopes in a region of gently rolling to rolling topography. In the regions where the Summit silt loam is the dominant soil, the Shelby loam usually occurs on the slopes of what are probably filled-in valleys. In the loessial region it occurs on slopes from which the later deposits of silty material have been washed. The type has good drainage.

This is an important soil in the agriculture of the county. Approximately 80 per cent of it is under cultivation. The remainder is in the native prairie sod and is used for pasture. A considerable proportion of the original covering, which consisted of such prairie grasses as bluestem and grama grass, has been displaced by bluegrass, which is extremely persistent.

Most of this type is well adapted to the use of labor-saving machinery. All the common crops of the region are grown. Wheat is the cash crop. Ordinarily not enough corn and hay are produced

to supply the home demand. Red clover and timothy are the main hay crops, though some bluegrass is cut on the more rolling areas. Alfalfa grows well, and the acreage in this crop is being extended. Inoculation is essential to good stands on new land. Probably more commercial apple orchards are on this type than on any other in the county. The trees produce well if properly cared for. One orchard of nearly 800 acres is located largely on this type northwest of Tonganoxie.

Important branches of the live-stock industry include the raising of hogs, the raising and fattening of beef cattle, dairying, and the raising of sheep. A number of purebred Shorthorn herds are found on this type in the western part of the county. Dairying in conjunction with general farming is generally practiced, and a number of large herds of dairy cattle are found in the vicinity of Tonganoxie and within trucking distance of that town.

Ordinarily corn yields from 17 to 20 bushels per acre on this soil, though much larger yields are obtained in very favorable years. Wheat produces from 15 to 20 bushels per acre in the average year, and oats from 25 to 35 bushels. Clover and timothy mixed yield 1¼ to 1¾ tons of hay per acre; clover alone, 1 to 1¾ tons; timothy, 1 to 1½ tons; and alfalfa, 2½ to 3 tons. Sudan grass, though grown only in small fields, yields about 3 tons of hay per acre. The grain sorghums and sorgo (saccharine sorghum) produce well.

This soil is easily cultivated and maintained in good tilth throughout the year. It warms up quickly in the spring and can be cultivated and seeded early. Systematic rotation of crops is not generally practiced, but the value of changing crops in a field every other year is generally recognized. Good results are obtained by the best farmers from the crop rotation and the methods of handling that are used on the Summit silt loam. Corn yields decline where the crop is grown on the same land many years in succession. Alfalfa is not used in rotations because of its long life on this soil; it has been known to produce profitably for 12 or 14 years. For permanent pastures bluegrass usually is seeded alone.

Commercial fertilizers are being used on this soil by many farmers in the southern part of the county. The most common fertilizer used is bone meal, either steamed or raw. This is applied at the rate of 75 to 150 pounds per acre, usually on wheat land. Under this practice wheat is said to yield an average of 22 to 27 bushels per acre quite consistently, and the succeeding crops are said to suffer less in droughty seasons.

Farms on the Shelby loam ordinarily sell for $125 to $175 an acre, with higher prices in the vicinity of a good market. Usually the price depends upon the condition of the soil, the topography, the location, and the improvements.

The use of a cover crop on some of the steeper slopes would prove beneficial in preventing washing and leaching. The addition of more organic matter, either in the form of barnyard manure or green-manure crops, is needed on some of the more rolling areas, especially where the soil has been washed thin. The reasonable use of commercial fertilizers high in phosphoric acid would give good returns on much of this soil.

Shelby loam, gravelly-subsoil phase.—The gravelly-subsoil phase of the Shelby loam is a dark-brown, mellow loam or light loam to a depth of 8 or 10 inches. The subsoil is a brownish-red silty clay loam containing considerable glacial gravel and resting at a depth of about 20 inches upon a bed of glacial gravel carrying a considerable proportion of brownish-red clay. The gravel consists chiefly of fragments of quartzite, gneiss, greenstone, and limestone. Gravel also occurs in many places in the surface soil.

Some areas of this phase in the central part of the county, indicated on the map by gravel symbols, contain large amounts of glacial gravel and bowlders throughout the entire soil section and on the surface. In many of these areas the fragments are numerous enough to interfere with cultivation. These areas would probably be mapped as gravelly loam if more extensive. One area in sec. 8, T. 12 S., R 22 E., has a fine sandy loam surface soil and contains considerable gravel on the surface.

The Shelby loam, gravelly-subsoil phase, occurs in small isolated areas scattered over that part of the county lying south of Fairholme and below the Oread escarpment. It occupies small, rounded knolls, narrow, elongated ridges, and the upper margins of slopes, but the total extent is small. Drainage is inclined to be excessive on account of the porous substratum of coarse material.

Only a very small proportion of this soil is in cultivation, and that is in very small areas in fields with other soils. It is handled the same as the adjacent soil, but yields are likely to be low in very dry years. The greater part of this soil originally supported a growth of prairie grasses, and in most of the areas the sod has never been broken. It is utilized almost entirely for pasture and the location of farmsteads.

SHELBY SILT LOAM.

The Shelby silt loam consists of a dark-brown silt loam, 12 inches deep, underlain by a yellowish-brown, moderately friable silty clay loam, passing at 24 to 27 inches, into a mottled yellowish-brown and grayish-brown, rather friable silty clay loam. The surface soil is moderately high in organic matter. The subsoil contains a small quantity of glacial grit, but not as much as is usually found in the

associated Shelby loam. In places the upper subsoil is rather compact but less compact than in the loam type. Near areas of Crawford soil the lower subsoil is in places reddish brown. Where the glacial deposit is thinnest the lower subsoil may contain fragments of sandy shale and resemble the lower part of the Bates soils. The line between the Shelby and the Summit silt loams is commonly very indefinite, and the line of separation between it and the Muscatine silt loam is also indistinct, especially where the content of glacial grit is very low. The Shelby silt loam prevailingly has a more granular subsoil than the Muscatine.

Most of the Shelby silt loam lies north and west of the Lawrence Branch of the Union Pacific Railroad. It usually occurs as good-sized areas lying on the divides or on the slopes near stream heads. The surface is gently rolling and the drainage is good. This is an important agricultural soil. Practically all of it, except a small acreage of pasture land, is utilized for cultivated crops. It is devoted to the same crops as the Summit silt loam, and these crops have the same relative importance and practically the same yields as on the latter. The methods of handling the soil are practically identical on the two types. Probably more alfalfa in proportion to the other hay crops is grown on the Shelby than on the Summit. Practically no commercial fertilizers are used. It is a more common practice to return the barnyard manure to the land on this type than on the Shelby loam.

Farms on the Shelby silt loam sell for as much as those on the Summit silt loam.

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

Mechanical analyses of Shelby silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381654	Soil	0.6	1.5	1.5	5.5	6.9	63.3	20.8
381655	Subsurface	.5	1.5	1.4	6.4	8.5	54.7	27.1
381656	Subsoil	.5	2.2	2.1	9.1	8.4	53.1	24.7

LINDLEY LOAM.

The surface soil of the Lindley loam, to a depth of 8 to 12 inches, is a grayish-brown mellow loam low in organic matter. The subsoil is a mottled reddish-brown, yellowish-brown, and grayish-brown silty clay loam, compact in the upper part but becoming more friable with depth. In places the rather compact nature of the subsoil continues to the 3-foot depth. Locally the grayish-brown mottling is

prominent only in the lower subsoil. The entire soil section contains some glacial grit, and occasionally a glacial bowlder or a few small pieces of chert are found on the surface. The lower subsoil usually contains numerous brown to reddish-brown iron stains. Where exposed in road cuts the subsoil often weathers to a brownish-red color, though on the broader divides the red color may be entirely absent from the soil section. On some of the steeper slopes a substratum of sandy shale is exposed in very narrow outcrops.

An important variation in this type, as mapped, occurs in the loessial region west and south of Lansing, and south of Lowemont. Here the surface soil is a shallow layer of buff-colored to grayish-brown silty material with which has been mixed considerable glacial material from the underlying deposits. The subsoil is a reddish-brown or mottled reddish-brown and yellowish-brown, rather compact silty clay loam, which in places becomes more friable and contains grayish-brown mottlings in the lower part.

The Lindley loam occurs in small areas in all parts of the county. These normally lie on the slopes to the larger creeks or on the narrow divides immediately above the limestone escarpment. Its topography is gently rolling or rolling to sloping. The slopes are rather steep, and in many places the run-off is rapid.

This soil is not very important in the agriculture of the county because of its small extent. Less than half of it is under cultivation, and many fields formerly cultivated have been returned to pasture. Most of it was originally forested, chiefly with oak, elm, wild cherry, hickory, and hackberry. Some forest still remains on the more rolling areas.

The cultivated part of the type is devoted chiefly to wheat, oats, hay, and corn. Small grains yield well, but corn ordinarily does not produce as well as on the darker colored Shelby soils. Considerable timothy and clover is grown. Grain sorghums and Sudan grass are among the more successful crops.

The Lindley loam can usually be purchased for $80 to $125 an acre where found in areas large enough to include a whole farm. The price depends largely upon the topography, state of cultivation, the nature of the native growth if uncultivated, the location, and the improvements.

The most urgent needs of this soil are organic matter and the control of erosion.

LINDLEY SILT LOAM.

The surface soil of the Lindley silt loam, to the depth of 8 to 10 inches, is a grayish-brown silt loam. The subsoil is a silty clay loam, mottled reddish brown, yellowish brown, and grayish brown to a depth of about 27 inches, and below this with yellowish brown and

grayish brown. The entire subsoil is rather compact, though in places it becomes more friable in the lower part. It frequently contains considerable glacial grit. In some places, especially on the flatter areas, the subsoil is yellowish brown in the upper part and mottled yellowish brown and gray in the lower. The surface soil is low in organic content.

One variation in this soil occurs in the loessial region of the county, especially south of Lansing. Here the surface soil is a light-colored loessial material usually of such depth that it is not mixed with the underlying glacial material in plowing. The subsoil is usually a mottled reddish-brown, yellowish-brown, and grayish-brown silty clay loam containing considerable quantities of glacial gravel and other rock fragments.

The Lindley silt loam is of small extent in this county. Most of it occurs as small, isolated areas on the narrow divides east of Stranger Creek, and on the low, gentle slopes along Wolf Creek. The drainage is good.

This soil originally supported a growth of prairie grass on the higher levels and forest on the lower. Much of it has been put under cultivation, though a considerable part is used for grazing cattle or sheep. The same crops are grown and practically the same yields are obtained as on the Lindley loam, and the soil is handled in much the same way as that soil.

MUSCATINE SILT LOAM.

The Muscatine silt loam consists of a dark grayish brown to dark brown, smooth silt loam, which grades at about 15 inches into a yellowish-brown to buff-colored, rather compact, light silty clay loam. The transitional layer between the surface and subsurface material may be slightly mottled with dark brown and yellowish brown as a result of the leaching down of organic matter from the surface soil. The lower subsoil, beginning at about 27 inches, is in most areas more friable than the upper subsoil. It is a mottled yellowish-brown and grayish-brown, or yellowish-brown and gray, light silty clay loam, with occasional bands of reddish-brown iron stains. The surface soil is moderately high in organic matter.

In a few spots, particularly in areas where the loessial material is deeper, the entire subsoil is friable; in others the entire subsoil is compact. Occasionally gray or grayish-brown mottlings are present in the upper subsoil as well as in the lower. In spots where the loessial material is underlain at shallow depths by limestone, the lower subsoil has a reddish-brown cast. The surface soil is deepest on the flatter divides and at the base of slopes, and shallowest on the steeper slopes. On slopes where erosion has been very active the subsoil is exposed in places, and the resulting soil is a heavy

silt loam of yellowish-brown color. These spots are not large enough to separate on the map. Scattered limestone outcrops of very small extent occur above the main line of the escarpment on the slopes of deeply cut valleys.

This soil is derived from the weathering of Missouri loess. In this county the mantle of this material varies considerably in thickness. Depths of 30 or 40 feet are recorded from well borings close to the Missouri River, but the average thickness farther from the river is probably not over 5 or 6 feet. The material immediately underlying this loessial mantle is a reddish-brown or yellowish-brown, mottled with gray, glacial débris, or, where this material is absent, a mottled gray or drab, brown, and yellowish-brown, moderately friable, residual silty clay loam or silty clay. The line between this soil and the Clinton silt loam is very indefinite in many places because of the similarity of soil materials. The compactness of the upper subsoil is probably due to a concentration of clay particles leached down from the surface soil. The gray mottles in the subsoil do not always have distinct boundaries, the color blending with surrounding colors.

The Muscatine silt loam occurs in a region of rolling topography in the northeastern part of the county. Its western limit approximates a line from the northwestern corner of Wyandotte County to the point where Stranger Creek enters Leavenworth County. It occurs both above and below the escarpment line and occupies the broader divides and more gentle slopes. Drainage is good. The valleys are V-shaped with well-rounded slopes. On many of the steeper slopes back from the river the Shelby loam is exposed, on others the Clinton silt loam.

The Muscatine silt loam is an important agricultural soil. Nearly all of it not occupied by towns, farmsteads, and institutions is cultivated. Originally most of the higher divides were covered with prairie grass, and many small pastures still remain in the native sod. Considerable timber grew on the slopes.

General farming prevails on this type. The most important crops grown are corn, wheat, hay, and oats, named in the order of their importance. Dairying and the raising of hogs and beef cattle are the most important live-stock industries. Dairying is usually carried on in conjunction with general farming, but a number of farmers in the vicinity of Leavenworth make it a specialty. There are a number of purebred dairy herds, chiefly Holstein-Friesian.

This soil is highly esteemed for fruit growing and supports a number of small commercial apple, cherry, and pear orchards. Many small patches of strawberries, blackberries, and raspberries are grown in the vicinity of the towns. Grapes do well. A number of small truck farms are situated near Leavenworth. The garden crops grown

with good results are sweet corn, Irish potatoes, tomatoes, cabbage, cucumbers, and onions.

This soil ordinarily produces 20 to 30 bushels of corn per acre, 15 to 22 bushels of wheat, and 35 to 45 bushels of oats. Clover alone yields 1½ to 2 tons; timothy alone, 1¼ to 1¾ tons; and alfalfa, in several cuttings, 3 to 4 tons of hay per acre. Potatoes do well where the organic matter content of the soil is high.

Most of the Muscatine silt loam is retentive of moisture and crops rarely suffer seriously from drought. The surface soil turns up mellow from the plow and can be cultivated under a comparatively wide range of moisture conditions. By employing the proper methods of handling, such as are followed by the more successful farmers, the productiveness of this soil can be easily maintained. The best farmers recognize the value of crop rotation and follow a definite system. They usually grow corn 2 years, oats 1 year, wheat 1 year, followed by clover 2 years, after which the land is returned to corn. Very little grain sorghum is grown, and only occasional patches of sorgo (saccharine sorghum) for sirup. Permanent pastures are usually started by sowing bluegrass.

Barnyard manure is commonly returned to the land and is usually applied to fields intended for small grain. An experiment, in cooperation with the State experiment station, on this soil south of Kickapoo, failed to show profitable returns from the use of commercial fertilizers.

Farms on the Muscatine silt loam are, as a rule, well improved and well cared for. The usual selling price of land of this type, where adapted primarily for general farming, is $150 to $250 an acre. Higher prices are paid in the vicinity of Leavenworth for truck farms and orchards.

The more general use of rotations would aid in maintaining and increasing the productiveness of this type as a whole. A liberal supply of organic matter, which may be supplied either as barnyard manure or as green-manure crops, would improve the tilth and increase production on the steeper slopes, where the subsoil occurs at shallow depths.

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

Mechanical analyses of Muscatine silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381665	Soil	0.1	0.4	0.4	1.3	9.2	69.4	19.5
381666	Subsurface	.0	.1	.1	3.3	8.6	59.2	29.0
381667	Subsoil	.0	.0	.0	1.8	13.3	59.9	25.3

GRUNDY SILT LOAM.

The surface soil of the Grundy silt loam is a dark-brown to nearly black, moderately heavy, smooth silt loam, rather high in organic matter. The subsoil, beginning at 18 or 20 inches, is a mottled dark-drab and dark yellowish brown or dark brownish yellow, compact silty clay, which becomes lighter colored with depth. The clay content increases with depth from the surface to 36 inches or more. The lower subsoil in places contains numerous reddish-brown to very dark brown iron stains.

The Grundy silt loam occurs as small bodies only in the northwestern part of the county. It lies on the highest flat divides within areas of Muscatine silt loam or Summit silt loam. The surface is flat to gently undulating, and the drainage is slow in some of the more level spots. A few farmers have corrected this condition by the use of tile drains. The depth of the surface soil is sufficient to give storage room for sufficient moisture to mature the ordinary crops.

This soil is inextensive in this county, but it is all under cultivation and highly esteemed by the farmers. It is devoted chiefly to corn, hay, wheat, and oats. Corn yields an average of 40 to 45 bushels per acre, and yields of 70 to 85 bushels are not uncommon. Wheat ordinarily yields 18 to 25 bushels per acre, and oats, 45 to 55 bushels. A considerable acreage is devoted to red clover and alfalfa. These crops do well, yielding 1¼ to 2 tons and 3 to 4 tons of hay per acre, respectively.

This soil is handled in much the same way as the Muscatine silt loam. It sells for $150 to $250 an acre, depending chiefly upon the location, improvements, and drainage.

CLINTON SILT LOAM.

The surface soil of the Clinton silt loam consists of about 12 inches of grayish-brown to buff-colored or brownish-gray smooth silt loam. This is underlain by a rather compact, buff-colored to brownish-yellow, light silty clay loam, which rests on a more friable silt loam or light silty clay loam, mottled brownish yellow and yellowish gray or gray. The surface soil is low in organic matter. The compactness of the upper subsoil is probably due to concentration of clay particles leached down from the surface soil. In places it is slightly mottled or spotted with silty material. Reddish-brown iron stains occur here and there in the lower subsoil. In a few places the brownish-yellow color continues throughout the entire subsoil.

Very small strips quite similar to the Knox silt loam occur in that part of the type adjacent to the Missouri River bluffs in the vicinity

of Pope and Maltby. A few spots or strips occur on the more rolling slopes from which the surface silty layer has been removed by erosion. The resulting soil is a buff-colored, heavy silt loam or light silty clay loam, which in larger areas is mapped as the Clinton silty clay loam. In road cuts the lower subsoil has a reddish-yellow color. In forest areas the surface 2 or 3 inches may be brown or dark grayish brown in color, owing to the accumulation of leaf mold, but this difference is soon lost when the soil is put under cultivation.

This soil is derived from reworked Missouri loess. It differs from the light-colored loess soils mapped farther north and immediately across the river chiefly in having a more compact upper subsoil.

The Clinton silt loam is developed in the northeastern part of the county. It occurs in a region of rolling to gently rolling topography and lies chiefly on narrow divides and slopes. It is dissected by distinctly V-shaped valleys with well-rounded slopes. Much of the type occurring on the narrow divides above the escarpment lies in narrow, irregularly shaped bodies, cut in many places by areas of other soils occupying deeply eroded drainage ways. Drainage over the type as a whole is good, and may be excessive on some of the steeper slopes.

Practically all the Clinton silt loam is under cultivation, only the more rolling areas being in their natural condition. It is devoted to the same crops and industries as the Muscatine silt loam and is farmed in the same manner. It is a good fruit soil. A small acreage is devoted to tobacco growing, with fairly good results. That part of the type ocurring on the divides was originally covered with a growth of prairie grass, while the more rolling sections were forested, chiefly with oak, elm, black walnut, ash, and hackberry. Most of the more rolling areas are used for pasture.

Corn on the Clinton silt loam ordinarily yields 15 to 20 bushels per acre; wheat, 12 to 17 bushels; oats, 30 to 40 bushels; red clover, 1 to 1½ tons; timothy, 1 to 1¼ tons; and alfalfa, 2½ to 3½ tons. Considerable sorgo (saccharine sorghum) is grown for sirup production in the more rolling sections.

A large quantity of barnyard manure is applied to this soil when used for truck or garden crops. The soil is easily worked and quite responsive to manurial treatment.

The Clinton silt loam has a wide range in price. Where more rolling and farther from markets it sells for $85 to $125 an acre. The better located and more level part of the type is held at $150 to $250 an acre.

The improved methods beneficial to the Muscatine silt loam prove of equal or even greater value on the Clinton soil.

CLINTON SILTY CLAY LOAM.

The surface soil of the Clinton silty clay loam, to the depth of 6 to 10 inches, is a brownish-yellow or buff-colored silty clay loam. The subsoil is a mottled brownish-yellow or buff-colored and gray or yellowish-gray, compact silty clay loam, which commonly shows numerous reddish-brown iron stains. The surface soil is low in organic content, and in places has a shallow covering of silty material. The upper subsoil in places is buff colored and free from mottling. The lower subsoil is quite friable in spots, and where underlain by limestone at a shallow depth has a reddish-brown color.

The Clinton silty clay loam is a soil of small extent. It occurs in the northeastern part of the county as small, isolated areas, on very narrow ridges or eroded slopes in areas of the Clinton silt loam. The drainage is good to excessive.

Most of this soil is under cultivation in fields with adjacent soils. It is devoted to the same crops as those soils, is farmed in a similar manner, and will produce nearly as good yields.

The Clinton silty clay loam occurs in fields with other types and is not sold alone. It is held at the same prices as the associated soils.

This soil is a little more difficult to handle than the silt loam, because of its greater clay content. Its tilth as well as its productiveness can be greatly improved by the addition of organic matter. Some of it is subject to erosion, and such areas should be kept in protecting crops as much of the time as practicable.

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

Mechanical analyses of Clinton silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381646	Soil	0.0	1.1	1.4	3.9	11.8	57.2	24.5
381647	Subsoil	.0	1.5	1.7	10.0	8.5	59.6	18.8

KNOX SILT LOAM.

The Knox silt loam occurs in only one small area in the extreme northeastern corner of the county along the bluffs to the Missouri River. This area is, however, typical. The type differs from the Clinton silt loam chiefly in the absence of the rather compact upper subsoil layer that characterizes the latter.

The soil consists of a light grayish brown or buff-colored, smooth silt loam grading at about 12 inches into an open, friable silt loam.

The lower subsoil is buff to light brownish yellow and in places contains rusty-brown iron stains. The surface soil is low in organic matter. There is little difference in the material either in color, texture, or structure to a depth of 36 inches. When exposed in cuts it stands in vertical walls for many years without noticeable erosion.

The surface of this type is rolling, and some of the steeper slopes are subject to erosion. The soil is nearly all under cultivation, the same crops being grown and the same yields obtained as on the Clinton silt loam. These two soils have about the same value.

The Knox silt loam is very retentive of moisture and is easily handled. It can be improved by practices that are beneficial to the Clinton silt loam.

Knox silt loam, steeply-rolling phase.—The steeply-rolling phase of the Knox silt loam includes areas along the bluffs of the Missouri River which are too steep for farming. The areas have a range in elevation from the higher to the lower margins of 100 to 200 feet. Outcrops of limestone are common.

The phase differs from the Crawford stony loam chiefly in the dominance of a buff or light-colored silty soil on the surface, and the smaller exposures of limestone. Practically all of this phase is devoted to pasture. It supports a good growth of trees consisting chiefly of oak, elm, walnut, cottonwood, sycamore, and wild cherry. Considerable grass grows in the areas of sparse forest growth.

DERBY FINE SANDY LOAM.

The surface soil of the Derby fine sandy loam consists of a grayish-brown fine sandy loam about 15 inches deep. In many uncultivated areas, and in fields that have had large amounts of organic matter added, the surface soil is a dark grayish brown. The subsoil is a yellowish-brown to reddish-yellow, heavy fine sandy loam, which grades downward into a loamy fine sand or clayey fine sand. At the base of slopes or in filled-in swales the surface soil is likely to be much deeper than on the upper slopes, where the surface soil may be washed very thin. Considerable coarse sand occurs in places in the soil that lies on the slopes to the river bottoms.

This soil is apparently of wind-blown origin. It is developed only in narrow strips on the slopes to the Kansas River bottoms and occupies a position between the Derby loam and the bottom soils. The surface is moderately rolling.

Over half of the type supports a growth of bunch grass and forest trees and is used as pasture land. The trees are chiefly oak, hickory, hackberry, and elm. Many of the slopes are too rolling to permit profitable cultivation.

This soil, where cultivated, is devoted chiefly to corn and hay crops. Corn ordinarily yields 15 to 20 bushels per acre, the yield depending considerably upon the depths of the soil and the cultivation. Alfalfa and clover do well. Not much small grain is grown, as the soil is too light for the best results. Sorghums give good yields. Several small apple orchards located on the type are proving profitable. Such truck crops as potatoes, melons, sweet corn, and muskmelons are grown commercially on a small scale in the extreme southwestern corner of the county. The land is valued highly for these crops.

The Derby fine sandy loam, where suitable for pasture, ordinarily sells for $75 to $100 an acre, and where improved for $125 to $200 an acre.

The most urgent need of this soil is more organic matter, which may be supplied either in the form of barnyard manure or green-manure crops.

DERBY LOAM.

The Derby loam consists of a grayish-brown to brownish-gray mellow loam, underlain at about 12 inches by a reddish-yellow to yellowish-red, friable, light silty clay loam, which becomes lighter colored and more friable with depth. The organic content of the soil is low. Northeast of Linwood the surface soil contains a relatively high percentage of silt and very fine sand. In some places adjacent to heavier soils the subsoil is not as friable in the upper section and is slightly mottled yellowish brown and reddish brown. In areas adjacent to bluffs bordering the Kansas River bottoms considerable coarse sand is usually found in the surface soil. Along Little Kaw Creek deposits of brownish-red glacial sand and gravel are encountered here and there in the lower soil depths. These deposits occur as small pockets.

From its almost continuous occurrence, its position just above the bluffs along the Kansas River, and its uniform material, it would appear that this soil is of wind-blown origin and that the materials have been brought from the river-bottom soils. The area varies in width from a few rods to nearly a mile. The surface is gently rolling, and the drainage is good.

Over three-fourths of this type is under cultivation, the rest supporting a sod of native grasses or bluegrass and is used for pasture. Some forest grows along the slopes. This consists chiefly of oak, hickory, elm, and hackberry. The soil is easy to cultivate and warms up early in the spring, permitting earlier planting than on the heavier residual soils.

The principal crops are corn, wheat, oats, and hay. Some sorghum and Sudan grass are grown. A few small fields of sweet clover are grown for hay and pasture, and a few of alsike clover for hog pas-

ture. Cattle are grazed on the pasture areas, and a few large herds are located near Linwood. Some dairying also is done in the vicinity of this town. Nearly every farm has a small herd of hogs.

In years of normal rainfall corn yields from 17 to 20 bushels per acre; wheat, 13 to 16 bushels; and oats, 25 to 35 bushels. Clover ordinarily yields 1 to 1½ tons of hay per acre; timothy, 1 to 1¼ tons; and alfalfa, 2 to 3 tons.

The Derby loam is farmed under the same general methods as the Shelby loam. Very little, if any, commercial fertilizer is used, but many of the farms have been brought to a good state of productiveness by the liberal application of barnyard manure.

Land of this type ordinarily sells for $100 to $200 an acre, depending upon the location and improvements.

This soil is in need of more organic matter. In some instances continuous cultivation to one crop has decreased the productiveness of the land, and the use of a crop rotation including a legume would be beneficial. On some of the steeper slopes the land should be kept in a cover crop much of the year to prevent washing.

BREMER SILT LOAM.

The Bremer silt loam is a dark-brown, friable, moderately heavy silt loam, which grades at about 15 inches into a dark-brown to dark brownish gray silty clay loam. The surface soil is high in organic matter. The lower subsoil usually becomes lighter colored with depth and contains numerous reddish-brown iron stains in the lower part. It is quite friable. In some of the smaller areas there is little change in color throughout the soil section.

In the zone of transition between this soil and the Chariton silt loam, and in poorly drained spots, the upper subsoil has a grayish cast for a few inches and the lower subsoil is more compact. These spots are of small extent. Near the outer margins of the type, adjacent to the drop in elevation to the overflow land, the subsoil under narrow strips of soil is better oxidized and has a yellowish-brown or mottled yellowish-brown and dark grayish brown color. In a few areas near Edminster, and in the loessial region of the county, spots occur where the lower subsoil is mottled yellowish brown and dark brown. Many of the areas lying below the Clinton soils have a surface covering of a few inches of lighter colored silty material.

The Bremer silt loam is derived chiefly from the soil materials found in the uplands of the county, reworked by running water and deposited on the stream-flood plains before the channels had cut to their present level. It differs but little from the Wabash silt loam, except in topographical position, and is but little older. It occurs on the second bottoms or benches above probable overflow along most of the creeks in the county. It receives considerable

surface water in rainy seasons from adjacent hills, and in a few spots adjacent to limestone and shale hills, it is wet from seepage in the spring months. These spots can best be reclaimed by tile drainage. The soil lies from 2 to 10 feet above the first-bottom land, and in many places the rise is so gradual as to be imperceptible to the eye. The soil is developed in small, discontinuous, narrow strips.

The surface of the Bremer silt loam is nearly level to very gently sloping toward the streams. On the type as a whole the drainage is fairly good, but in some of the larger areas the run-off is slow. Ditching has been done in places to hasten the removal of excess water.

With the exception of land occupied by farmsteads, towns, and a few small pastures, the Bremer silt loam is practically all under cultivation. The type is one of the most valuable alluvial soils in the county for general farm crops. It was originally forested, chiefly with oak, elm, walnut, hickory, sycamore, and a mixed underbrush. A good growth of grass flourished where the forest was not too thick.

The crops grown on this soil, in the order of their importance, are corn, wheat, hay, and oats. The chief branches of the live-stock industry are the raising and fattening of hogs and dairying. The hogs are pastured during the summer months on clover or alfalfa. The dairy cattle are usually pastured in summer on adjacent hill land or on lower lying types along the streams.

Ordinarily corn yields 25 to 35 bushels per acre. Corn has been grown many years in succession on many fields without appreciable decrease in yields. Wheat averages 15 to 20 bushels per acre, and oats about 45 bushels. In wet years these crops may grow too rank and lodge badly. Clover, the most important hay crop, yields from 1½ to 2 tons of hay per acre, and timothy from 1 to 1½ tons. Alfalfa is fast displacing clover as the main hay crop. It gives an average yield of 3 tons per acre per season.

Farm practices on this soil are similar to those on the Summit silt loam. The more progressive farmers maintain a definite crop rotation, the one most common, consisting of corn 2 years, oats 1 year, wheat 1 year, and clover 2 years, and back to corn. The soil is friable and easily cultivated. Except in the more level areas, it warms up quite early in the spring. No commercial fertilizer is used, but barnyard manure is applied in many cases to the land to be plowed for small grains. On account of the nearly level surface many tractors are in use on this type.

Land of the Bremer silt loam ordinarily sells for $150 to $225 an acre.

BREMER SILTY CLAY LOAM.

The surface soil of the Bremer silty clay loam is a dark-brown to nearly black silty clay loam, high in organic matter, and quite friable in the first 6 inches. The subsoil, beginning at about 18 inches, is a dark grayish brown or dark-brown silty clay, which becomes heavier and lighter colored with depth. The surface soil grades so gradually into the subsoil that there is no definite line between them. The subsoil in places contains numerous brown or rusty-brown iron stains in the lower part. In a few low-lying spots and spots adjacent to areas of the Chariton silt loam the upper subsoil is dark gray and the entire subsoil compact. The boundaries between this type and the silt loam of the series are rather indefinite.

The Bremer silty clay loam differs but little from the Wabash silty clay loam, except in topographic position. It occurs chiefly along Stranger, Ninemile, and Tonganoxie Creeks, though small, isolated areas lie along the other creeks in the western and southern parts of the county. It occurs as scattered, narrow terrace remnants lying 2 to 10 feet above probable overflow. The surface is flat, with possibly a slight slope toward the streams. Drainage over the type as a whole is fairly good, but is slow in some of the more level areas. Ditches are needed to carry off the surface water and to lower the water table, if the land is to be planted early in the growing season.

Nearly all of the Bremer silty clay loam is under cultivation. It is very productive. The principal crops are corn, wheat, hay, and oats. Yields are about the same as on the closely associated Bremer silt loam, and the methods of farming on the two types differ little.

The selling price of land of this type ordinarily ranges from $150 to $225 an acre.

CHARITON SILT LOAM.

The surface soil of the Chariton silt loam consists of a dark-gray, smooth silt loam 12 or 14 inches deep. This is underlain by an ashy-gray silt layer, 5 or 6 inches thick, which rests upon a nearly black, compact silty clay or clay. The surface is only moderately high in organic matter. In spots where the surface soil is thin and is mixed with the subsurface layer through tillage operations, it has a light-gray appearance when dry. Near the terrace margins the subsoil may be slightly mottled, either gray and dark brown or gray and yellowish brown, but it does not lose its compact nature. In a few places the gray layer is very thin. Near the center of the larger areas near Reno the lower subsoil becomes lighter colored with depth and in a few places has a drab or olive-drab color.

The Chariton silt loam is one of the most extensive terrace soils in the county. It occurs chiefly along the small creeks in the south-

ern half of the county. It is similar in development and position to the Bremer silt loam, with which it is frequently associated. It was probably formed mainly under standing water held in obstructed drainage ways before the streams cut to their present levels. Surface drainage is fairly good but underdrainage is rather poor on account of the impervious nature of the subsoil.

Most of this soil is under cultivation. It is devoted to the same crops as the Bremer silt loam, though probably a greater proportion is used for the production of small grains. The uncultivated parts are used for pasture and support a good growth of native grasses and forest.

The crop yields on the Chariton silt loam will average nearly as high as on the Bremer silt loam, except that where the surface soil is very thin the yields are likely to be lower in dry seasons.

The Chariton silt loam sells for $100 to $200 an acre. Where it is sold in farms with other soils its price is influenced by the comparative value of such soils.

Much of this soil would be greatly benefited by building up the supply of organic matter, either by applying barnyard manure or plowing under green-manure crops.

WAUKESHA VERY FINE SANDY LOAM.

The Waukesha very fine sandy loam consists of a dark grayish brown to dark-brown mellow very fine sandy loam, underlain at about 18 inches by a very dark brown, heavy very fine sandy loam to loam. The surface soil is moderately high in organic matter.

This soil occurs only on terraces in the Kansas River bottom southwest of Linwood and southwest of Six Corners. It lies on a bench about 15 feet above the general level of the first bottom and is not subject to overflow. The surface is nearly level, with a slight slope toward the first bottom, and drainage is good.

Though not extensive this soil is rather important locally. It is all under cultivation and devoted chiefly to corn, potatoes, wheat, oats, and alfalfa. It is very productive and is valued as highly as any alluvial soil in the county. It is easy to handle and warms up earlier in the spring than any of the other terrace soils.

In normal years corn yields 30 to 45 bushels per acre, and a maximum yield of 70 to 80 bushels is not uncommon on the better parts of the type in favorable seasons. Alfalfa gives three or four cuttings a season, with a total yield ranging from 3 to 4 tons of hay per acre. Potatoes yield from 80 to 90 bushels per acre.

WAUKESHA SILT LOAM.

The Waukesha silt loam as mapped in this county is quite variable. The typical soil is a dark-brown to a dark grayish brown, friable silt

loam overlying at about 14 inches a yellowish-brown, friable silty clay loam. The surface soil is moderately high in organic content. In those areas in the vicinity of Lansing the soil consists of 10 or 15 inches of dark grayish brown to dark-brown silt loam underlain by a grayish-brown, heavy silt loam, which grades at about 20 inches into a mottled yellowish-brown and yellowish-gray or mottled dark-brown and yellowish-brown friable silty clay loam. In an area south of Hund the subsoil is more compact, and resembles in color and structure that of the Summit silt loam, but the entire soil section nearly everywhere is friable. Reddish-brown iron stains are not uncommon in the lower subsoil. In places the surface soil is lighter colored, on account of a shallow wash derived from adjacent Clinton soils.

The soil is derived chiefly from loessial material reworked and deposited on the old flood plains of streams. The type occurs only as small, discontinuous terrace remnants, lying above overflow, in the northeastern part of the county. These terraces are from 5 to 15 feet above the first bottoms. The surface is nearly flat, except where cut by streams issuing from the adjacent upland. The areas have slope enough toward the drainage ways to insure good drainage.

Practically all of the Waukesha silt loam is under cultivation. It is devoted to about the same crops as the Muscatine silt loam and is handled much the same. Probably a somewhat large proportion of the cultivated land is devoted to corn. The yields obtained are about the same on the two types.

The Waukesha silt loam is usually sold in farms with the adjacent types.

WABASH LOAM.

The surface soil of the Wabash loam consists of about 18 inches of a dark-brown mellow loam. This is underlain by a dark brownish gray heavy loam to light silty clay loam, which gradually becomes lighter colored in the lower part of the 3-foot section. The surface soil is high in organic matter. The lower subsoil here and there contains numerous reddish-brown iron stains. In places there is little perceptible difference throughout the soil section, the material being a dark-brown loam, but generally the subsoil is more compact than the surface soil. The surface soil is usually heavier in the lower lying parts of the type, back from the channels of the streams. Along some of the very narrow stream bottoms the surface soil passes from a very fine sandy loam to a heavy loam in short distances.

The Wabash loam is not very extensive in this county. It has its greatest development along the smaller creeks in the southern part of the county, along Wolf Creek, and as small isolated bodies along the larger creeks. Along the smaller creeks it occupies the whole of

the overflow land, while along others it occurs along the banks or in bends of the stream channels and is surrounded by other types. Practically all the type is subject to overflow nearly every year. The surface as a whole is nearly flat, though numerous old channels give it fairly good drainage.

Over half of the Wabash loam is under cultivation. Many of the lower lying and narrower areas are utilized for pasture. These areas are usually well covered with a forest growth consisting chiefly of oak, black walnut, elm, sycamore, and cottonwood.

This soil is naturally very productive and, excepting possible injury to the crops by overflows, very dependable. Corn, wheat, oats, and hay are the principal crops. Approximately the same yields are obtained as on the Wabash silt loam, and the farming methods employed are similar to those used on that soil. The land ranges in price from $150 to $225 an acre.

WABASH SILT LOAM.

The surface soil of the Wabash silt loam consists of a dark-brown to nearly black, friable silt loam, with a depth of about 18 inches. The subsoil is a dark brownish gray silty clay loam. The clay content increases with depth and the color becomes lighter. The surface soil is quite high in organic matter. The change in color and texture from the surface soil to subsoil is very gradual and in places imperceptible. In areas adjacent to the Clinton soils the surface soil may have a shallow covering of lighter colored silty material. In the better drained areas the lower subsoil in places contains small reddish-brown iron stains.

Along Ninemile Creek in the vicinity of Reno the entire soil section in places has a rich brown color, but the soil material differs little in texture or structure from the typical. In areas along the larger creeks that part of the type lying next to the stream may have a better oxidized subsoil and a grayish-brown to yellowish-brown color. In the glaciated sections of the county the streams have deposited considerable sand on the surface immediately along the stream channels. These areas are usually a loam in texture, but are too small to separate from the typical soil. A few small depressional or level spots occur where the surface is underlain by a thin layer of ashy-gray silty material, resulting probably from poor drainage.

The Wabash silt loam is derived chiefly as wash from the upland soils of the county. It is most extensively developed along Stranger Creek and its tributaries and the creeks in the loessial region. It occurs in long belts, ranging in width from a few hundred feet to 1 mile or more, and may comprise all, or nearly all, of the first-bottom land subject to overflow. Those areas along the larger creeks are flooded practically every year.

The surface of the Wabash silt loam is flat to gently undulating, except where cut by old channels and sloughs. Drainage is fairly good in most places.

Most of this type is under cultivation. It is one of the most productive soils in this part of the State, and were it not for the danger of overflow it would doubtless rank as one of the best soils in the county. In a way overflows serve to improve the type, as each leaves a deposit of rich soil material over the surface, unless the ground is newly plowed, in which case the rather swift currents are likely to do more damage than good. A considerable forest, consisting mainly of oak, elm, hickory, black walnut, and cottonwood, stands along the stream channels. Small areas next to the stream channels or in bends of the streams have been kept in pasture. The growth of grass is excellent.

Corn is the principal crop on the type. Yields of 60 to 90 bushels are not uncommon in years when the land is not flooded, and this is one of the best corn soils in the county. The corn is fed largely to live stock raised on the upland. Corn has been grown for years in succession on many fields on this type without a noticeable decrease in the yield. In years of normal rainfall and when the crop is not damaged by overflow wheat yields from 25 to 35 bushels per acre, and oats from 35 to 50 bushels. In wet years, however, these crops grow too rank and lodge badly. Much of the type will produce alfalfa and clover successfully. Alfalfa produces 3 to 4 tons of hay per acre, and red clover 1¼ to 1¾ tons. The type is well adapted to all of the grass crops. A considerable acreage of sorgo is grown for sirup production.

Many of the best farmers are applying barnyard manure to this soil and are using a short rotation, including clover, to maintain the soil in a state of high productiveness. Many say that the late planting of spring crops will in most years avoid injury from overflow. Very little plowing is done in the fall for spring crops, as the danger of washing by early spring floods is too great. The soil can be worked under a wide range of moisture conditions and turns up mellow from the plow.

Where the Wabash silt loam occurs in areas large enough to farm in separate fields, the land sells for $150 to $225 an acre, the price depending chiefly upon the frequency of overflow, the location, and how badly the land is cut by streams.

This soil is naturally productive, but continuous cropping to corn and severe floods have depleted the fertility of some fields. It is advisable to maintain the productiveness by applying barnyard manure, by plowing under green-manure crops, and by following a systematic rotation, rather than to allow the land to run down and

then attempt to build it up. Diking or straightening the streams where practicable, and keeping the streams free from logs and other drift, would do much toward preventing ordinary overflows.

WABASH SILTY CLAY LOAM.

The Wabash silty clay loam is a dark-brown to nearly black silty clay loam, underlain at about 18 inches by a dark brownish gray silty clay or clay. The subsoil is usually lighter colored in the lower part of the 3-foot section, but in some places the entire profile is nearly black. The subsoil here and there contains numerous reddish-brown iron stains. As a whole, the soil is quite uniform. It is more friable than the Wabash clay and does not crack so badly.

The Wabash silty clay loam is alluvial in origin and is developed chiefly as low-lying bodies or strips back from the channel along Stranger Creek. Overflows are more or less frequent. The surface is flat, and water is slow to run off after heavy rains and floods. The drainage is poor, except where the land has been drained by artificial means.

Probably half of this soil is under cultivation, the remainder being in the native grasses and furnishing good pasturage and hay crops. It is a strong soil. The leading crops are corn, wheat, and oats. When not overflowed during the growing season the better drained areas produce yields as good as or better than those on the associated loam and silt loam types. Yields of 1 to 1½ tons of wild hay are cut.

The Wabash silty clay loam is more difficult to handle than the loam or silt loam types, but not as difficult as the clay. Heavy draft power and heavy implements are used in tillage. This soil does not warm up early in the spring, and care must be taken not to plow or cultivate when too wet, as it clods and dries out in hard lumps unless broken down immediately after turning. Several farmers have ditched this soil with profitable results.

Land of the Wabash silty clay loam ordinarily sells for about as much as the Wabash silt loam.

WABASH CLAY.

The soil of the Wabash clay is quite consistently a nearly black, waxy clay, which overlies at about 20 inches a dark brownish gray to dark-drab, moderately stiff clay. The line between the soil and subsoil is very indistinct. The upper soil section is high in organic matter. Near areas of silt loam a silty layer may cover the surface 2 or 3 inches deep.

The Wabash clay is known locally as "gumbo land." It is developed only along Stranger Creek and usually occurs as low-lying, level areas back from the stream channels. It was probably formed

under slow-moving or stagnant water. The natural drainage is poor and the surface is often covered with water for considerable periods after a heavy rain or floods.

About half of this soil is under cultivation, chiefly to wheat and corn. The yields are good in normal seasons, when not reduced by floods. Many large pastures are maintained on this type. Wild grasses cut from it yield 1¼ to 1¾ tons of hay per acre.

The Wabash clay is a very productive soil, and its fertility has apparently been but little impaired, even in the fields continuously planted to one crop.

Many areas have been improved by ditching. The soil is hard to handle and can be cultivated safely only under a narrow range of moisture conditions. It is sticky when wet and cracks upon drying. If plowed when too wet it clods and bakes, and when too dry it is hard to break. When worked in a fairly moist condition a mellow tilth can be maintained. Disking the field before fall plowing has given good results by causing the soil to turn more easily and break up into a better tilth. Five-horse and six-horse teams and tractors are used in tillage operations. It is one of the last soils to warm up in the spring.

Land values on this soil range from $100 to $175 an acre, depending chiefly upon drainage conditions and location.

The tilth of this soil could be improved by the addition of organic matter. Thorough ditching, to carry off the water rapidly, would cause it to warm up earlier in the spring.

SARPY FINE SAND.

The Sarpy fine sand consists of a loose, incoherent, brownish-gray fine sand which becomes lighter colored with depth.

This type is inextensive and is developed chiefly as long narrow strips within or adjacent to areas of the Sarpy fine sandy loam in the bends of the Kansas River. The surface is billowy. In most places the internal drainage is excessive on account of the porous nature of the soil material.

A very fine sand variation of this type occurs in areas along the banks of the Missouri River and on Kickapoo Island and Stigers Island. It occurs as almost continuous narrow bands and represents the more recent deposits of the river. It consists of a brownish-gray very fine sand grading into a light-gray very fine sand within 3 feet of the surface. The soil material is loose and incoherent.

Very little of the Sarpy fine sand is cultivated. Some of it is farmed in conjunction with adjacent soils. Small patches of garden vegetables, melons, and muskmelons are grown for home consumption. The soil is early and quite productive for these crops. A small

acreage is devoted to sweet potatoes and kafir on Stigers Island with good results. Most of the type supports a sparse growth of grass and trees. The trees are chiefly willow, cottonwood, oak, and sycamore. Much of the type is included in pastures.

The Sarpy fine sand is usually sold in farms with associated types. On account of its inaccessibility and the frequency of overflow, the very fine sand variation in the Missouri River bottom does not bring prices nearly as high as those obtained for similar soils in the Kansas River bottom.

SARPY FINE SANDY LOAM.

The Sarpy fine sandy loam consists of a brownish-gray fine sand to loamy fine sand, with an average depth of about 15 inches, overlying a brownish-gray to grayish-brown fine sandy loam or very fine sandy loam, which rests on a stratum of brownish-gray fine sand or very fine sand. In most places this soil appears to consist of a deposit of fine sand over what was originally a shallow very fine sandy loam soil. The surface is usually loose and low in organic matter. The entire soil section is usually calcareous. Throughout the areas of this type there are minor elevations of Sarpy fine sand that are too small to map.

This soil is developed in narrow bodies in the bends of the Kansas River. The areas lie adjacent to or parallel to the river, at slightly higher elevations than the associated type, the very fine sandy loam, and have a billowy to gently undulating surface. Drainage is good, and overflows seldom occur. In some of the higher lying areas, where the soil is more open and loose, yields are frequently reduced in dry seasons.

The Sarpy fine sandy loam is relatively inextensive in this county. About half of it is under cultivation, and the rest supports a growth of grass and is used for grazing. The greater part of the land under cultivation is devoted to corn and alfalfa. In favorable years corn yields nearly as well as on the very fine sandy loam, but in seasons of subnormal rainfall the yields are curtailed. Alfalfa averages 2½ to 3½ tons per acre. Very little small grain is grown on account of the loose, open nature of the soil. Grain sorghums do well. Watermelons, muskmelons, and other truck crops give good yields on this soil but are seldom grown except for home use. The best results are obtained where manure is applied liberally.

The Sarpy fine sandy loam is usually included in farms with other types, and a separate selling value can not be definitely given.

The most urgent need of this soil is organic matter, and under existing conditions this can probably be most profitably supplied through the growing and plowing under of a green-manure crop. Sweet clover has been used for this purpose with good results.

SARPY VERY FINE SANDY LOAM.

The Sarpy very fine sandy loam consists of a brownish-gray very fine sandy loam about 15 inches deep, underlain by a brownish-gray to dark brownish gray, heavy very fine sandy loam to light loam, which passes gradually at about 27 inches into a gray loamy very fine sand or very fine sand. The surface soil is very low in organic matter. The subsurface layer is usually darker in color than the surface soil. Spots occur adjacent to heavier textured soils, where thin layers of silty clay loam are found at varying depths below the surface. On some of the minor elevations the soil contains but little silt and is loose in structure. On the other hand, the surface soil in some of the lower lying areas may be quite silty. Both soil and subsoil effervesce with hydrochloric acid, showing the presence of considerable quantities of lime carbonate.

The Sarpy very fine sandy loam reaches its greatest development along the Kansas River, where it is the principal first-bottom soil. Small areas also lie in strips in the Missouri River flood plain. The surface of the soil is billowy to flat. Drainage is good. Except for one or two small areas of this soil adjacent to the bluffs near Lenape and the Wyandotte County line, it is all subject to overflow, but over most of the type floods are rare.

Practically all of this soil in the Kansas River bottom and most of that along the Missouri River is under cultivation. It is devoted chiefly to corn, Irish potatoes, and alfalfa. A considerable acreage of wheat and oats is grown. That part of the type not under cultivation is usually very low lying and supports a growth of trees, chiefly oak, elm, ash, cottonwood, sycamore, and willow. Some grass grows in the forested areas, but it does not produce as heavy a growth as on the heavier soils. This land is used for pastures.

Corn yields from 30 to 45 bushels per acre in average seasons, and as high as 70 to 90 bushels on the heavier variations of the type in favorable seasons. Wheat and oats are frequently sown, but they grow too rank in wet seasons on the heavier land of the type, and do not produce well on the lighter areas. Alfalfa does well on the average of this soil, produces three or four cuttings annually, with a total yield of about 4 tons per acre. Red clover produces about 2 tons of hay per acre. Sweet clover is not usually grown, except as a green-manure crop.

Irish potatoes have always been an important crop on this soil. They have been produced on some fields continuously for over 20 years. The Early Ohio is a favorite variety. It is a common practice to grow turnips in the fall and plow them under as a green manure, and by using this method of adding organic matter and fertilizer the yields have been maintained at an average of about

80 or 90 bushels per acre. The increase in the price of land in recent years has caused many farmers to study methods of increasing their yields. The most successful method, without using a crop rotation, is to grow sweet clover and turn under the crop as a green manure. Farmers report that by this method the yields have been increased from 200 to 250 per cent. In late years considerable loss has been caused by potato rot and other diseases. Successful methods of combating and preventing these diseases are discussed in a publication of the Kansas Agricultural Experiment Station.[9] Sweet potatoes, watermelons, and muskmelons all do well on this soil, but are not grown on a commercial scale to any great extent. Practically all other vegetables succeed, but owing to the distance from a large market they are not grown commercially.

The Sarpy very fine sandy loam is one of the earliest soils in the county. It is easy to cultivate and can be worked under almost any moisture conditions. Very little live stock is raised on this type, so there is very little manure available. Commercial fertilizers are not commonly used, and on account of the porous nature of the soil their value would be more or less temporary.

Land of the Sarpy very fine sandy loam along the Kansas River sells for $300 to $400 an acre. Along the Missouri River it occurs in very small areas or in rather inaccessible situations and is much lower priced.

This soil is naturally rather low in organic matter, and in many of the fields where the soil has been continuously under intensive cultivation the supply has been almost entirely exhausted. This condition could be remedied by a more general practice of plowing under such green-manure crops as sweet clover, or by the still better method of adopting a systematic crop rotation including a legume.

SARPY LOAM.

The surface soil of the Sarpy loam is a grayish-brown to brownish-gray friable loam, about 14 inches deep. The subsoil is a grayish-brown or brownish-gray, heavy loam to light silty clay loam, which passes at about 27 inches into a brownish-gray very fine sandy loam or loamy very fine sand. The surface soil contains a relatively high percentage of very fine sand and is rather low in organic matter. The subsurface layer in some of the lower lying areas of the type is dark colored. In most places the entire soil section is calcareous.

In some of the lower lying areas, particularly along depressions, old sloughs, or drainage ways, the surface soil is a silty clay loam, but areas of this kind are so small that it was not thought necessary

[9] Bul. 194, Kansas Agr. Expt. Sta.

to separate them. A few small ridges of silty clay loam, occurring in the Sarpy loam areas on Kickapoo and Stigers Islands, have likewise been included with the loam type.

The Sarpy loam is developed along the Kansas and Missouri Rivers in positions slightly lower than those of the lighter textured Sarpy soils. The surface is nearly flat with a general slope toward the streams. Surface drainage is good in most of the areas. Internal drainage is good on account of the light-textured substratum. The type is very seldom flooded.

Nearly all the Sarpy loam is under cultivation. For the most part the uncultivated areas are low lying or are on the islands and therefore inaccessible. They support a forest growth consisting chiefly of oak, sycamore, elm, cottonwood, and willow.

The most important crop on the Sarpy loam is corn. This crop does especially well on this soil. Wheat and oats give good average yields, but are inclined to grow too rank and lodge in wet seasons. Alfalfa and clover produce as much hay in the average year as on the very fine sandy loam. The loam is not as commonly used for Irish potatoes as the very fine sandy loam, but the yields are nearly as large.

The Sarpy loam is farmed much the same as its associated type, the very fine sandy loam, and in the typical areas is nearly as easy to handle. Little or no manure is applied, and very few farmers follow any definite system of crop rotation.

The Sarpy loam sells at practically the same price as the Sarpy very fine sandy loam.

SARPY CLAY.

The surface soil of the Sarpy clay consists of a dark grayish brown to grayish-brown or brownish-gray, heavy, tenacious silty clay or clay. The subsoil is quite variable and may consist of a brownish-gray to gray very fine sand, very fine sandy loam, or light silty clay loam. It is usually encountered at depths ranging from 20 to 27 inches. In some uncultivated areas the material of the surface few inches contains considerable organic matter and is dark colored. In a few places the lighter textured lower subsoil material is not encountered, and the heavy material continues to the 3-foot depth. In such cases it is mottled drab and grayish brown in the lower parts.

The soil occurs chiefly along the Missouri River near Kickapoo, near the center of Kickapoo and Stigers Islands, and in the Fort Leavenworth bottom-land holdings. It occupies low-lying positions and is subject to frequent overflow unless diked. The surface is nearly level, and water often stands on it for long periods after a heavy rain or flood. Old filled-in channels and sloughs are numerous.

Most of this type is covered with a dense forest growth, consisting mainly of oak, willow, cottonwood, elm, sycamore, and shrubby growths. This land is devoted principally to grazing. The cultivated part is used chiefly in growing corn and wheat. Some kafir and sorgo (saccharine sorghum) are grown. When not damaged by overflow these crops give good yields. Corn yields 60 to 90 bushels per acre if the land is properly cared for. Wheat yields 20 to 30 bushels per acre.

The Sarpy clay is a heavy, refractory soil. It warms up late in the spring and is hard to handle. Unless a mulch is carefully maintained it checks and cracks badly in dry seasons. When plowed too wet it bakes and is hard to granulate again.

If it were not for the frequency of overflow and rather isolated position of the areas, much more of this soil would be under cultivation than at present. The State penitentiary is diking its holdings on Stigers Island, and this, with proper surface ditching, should make that part occupied by the Sarpy clay a very good, consistently productive soil. The addition of organic matter would help to improve the tilth of the surface soil.

On account of its location and the frequency of overflow, most of the unimproved Sarpy clay can be bought for $40 to $60 an acre. The better improved land brings considerably higher prices.

RIVERWASH.

Small areas of coarse-textured soil occurring along the Kansas and Missouri Rivers are mapped as Riverwash. The material consists of a mixture of all grades of sand, which is shifted about or added to during each general rise of the stream.

Riverwash commonly occurs as sand bars in the rivers or as newly made fills on the side of the stream opposite to the cutting current.

Because of the frequency of overflow and the uncertainty of crop yields, this soil is not cultivated. Where not barren, the land supports a growth of willow or cottonwood sprouts and saplings.

SUMMARY.

Leavenworth County, Kansas, borders the eastern boundary of the State, and is separated from the northern boundary of the State by two counties. It comprises an area of 460 square miles, or 294,400 acres.

The surface of the county varies from undulating to rolling. The western and northern parts are separated from the remainder by a limestone escarpment which has a drop in elevation of 100 to 180 feet. The elevation of the land above the escarpment ranges from 1,000 to 1,100 feet above sea level and that below the escarpment

from 850 to 1,000 feet. The drainage is effected by the Missouri and Kansas Rivers. Practically every farm is reached by the intricate drainage system.

Extensive development of agriculture in the county began in 1854. Settlers crowded in from States to the east during the following two years. The population in 1920 was 38,402. Leavenworth, the county seat, in that year had a population of 16,912.

The county is well supplied with railroad facilities. It has 162 miles of main track. Local markets and Kansas City markets absorb most of the farm products offered for sale.

The mean annual temperature is 53.4° F. The mean annual rainfall is 34.74 inches. Over 70 per cent of the precipitation falls during the growing season. Blizzards and tornadoes are rare. The average growing season is 187 days.

The agriculture of Leavenworth County consists mainly of a combination of grain and dairy farming. Trucking and trucking combined with fruit growing are fairly important industries in the northeastern part of the county. The practice of feeding hogs in conjunction with dairying and grain farming is common in most parts of the county. Corn and wheat are the most important crops. Other important crops are oats, Irish potatoes, red clover, alfalfa, timothy, and grain sorghums.

The labor supply is plentiful but is transient and rather unsatisfactory.

There are 2,115 farms in the county, with an average size of 127.9 acres. Nearly two-thirds of the farms are operated by owners. Farm land rents for $4 to $10 an acre. In share renting, one-third to one-half the production goes to the owner, with cash rent for the hay and pasture land.

Prices of farm land in Leavenworth County range from $100 to $225 an acre for good upland and creek-bottom land, to $250 to $400 an acre for land in the Kansas River bottoms.

The soils of Leavenworth County may be divided according to the method of accumulation into four broad groups—residual, glacial, loessial, and alluvial.

The residual soils of the county are classed in the Summit, Crawford, Boone, and Bates series. The Summit silt loam is the most important soil of this group.

The Summit silt loam occurs in all parts of the county except the loessial region north and northwest of Leavenworth City. The surface is undulating or gently rolling. It is the most extensive upland soil and one of the most desirable for general farming. The Summit clay loam usually occurs as narrow strips at the base of the escarpment south of Jarbalo. When thoroughly drained it is a very desirable soil for general farming and alfalfa.

The Crawford silty clay loam occurs in all parts of the county where the basal limestone is exposed. The Crawford stony loam comprises areas of land too stony or rocky for profitable cultivation. It includes nearly all the limestone outcrops and is usually included in pastures.

The Boone loam occurs chiefly as small bodies in that part of the county below the Oread escarpment. The surface is gently rolling to rolling. The type is rather extensive, and about half of it is devoted to the production of farm crops, chiefly wheat, oats, hay, corn, and grain sorghums. The Boone very fine sandy loam is widely scattered in small areas over the southern part of the county. Very little of it is under cultivation. The Boone silty clay loam is developed as long, very narrow strips on the slopes where the various beds of shale are exposed. Most of it has a rather low agricultural value.

The Bates loam occurs in a section of gently rolling to rolling topography in the southern part of the county.

The glacial soils of the county are included in the Lindley and Shelby series. The Shelby soils are the most important of this group.

The Shelby loam is a very important soil in the agriculture of the county. It occurs in all parts of the county in a gently rolling to rolling topography. All the crops common to this region are produced on it and yield well.

The Shelby silt loam occurs almost entirely to the north and west of the Lawrence Branch of the Union Pacific Railroad. The surface is gently rolling. This is an important agricultural soil. It ordinarily gives good yields of the common crops of the region.

The Lindley loam lies in small bodies on slopes and narrow divides in all parts of the county. It is devoted chiefly to pasture grasses, wheat, and oats. The Lindley silt loam occurs as small isolated areas on narrow divides and has about the same agricultural value as the loam.

The loessial soils are included in the Muscatine, Grundy, Clinton, Knox, and Derby series. Of these soils the Muscatine silt loam and the Clinton silt loam are the most important types.

The Muscatine silt loam lies on the broader divides and gentler slopes. Most of it is cultivated. It produces good yields of all the crops commonly grown in this region and is highly esteemed for fruit growing.

The Grundy silt loam is developed in small bodies on high, flat divides. It is highly esteemed and is all under cultivation.

The Clinton silt loam occurs chiefly on narrow divides and slopes. It is devoted to general farm crops, with some pasture, and supports several commercial apple orchards. The Clinton silty clay loam occupies eroded slopes in the Clinton silt loam.

The Knox silt loam borders the Missouri River bluffs and is utilized much the same as the Clinton silt loam.

The Derby loam is developed on the bluffs along the Kansas River. It produces good average yields of corn, wheat, oats, and hay. The Derby fine sandy loam occurs on slopes extending to the Kansas River bottoms. The rougher part is used for grazing. Good yields of truck crops are produced on the type in the southwestern corner of the county.

The alluvial soils of the county may be subdivided into terrace soils, which lie above all overflow, and first-bottom soils, which are subject to overflow.

The terrace soils include the Bremer, Chariton, and Waukesha soils.

The Bremer silt loam is a valuable soil, producing consistently good yields of general farm crops. The chief crops are corn, wheat, hay, and oats. The Bremer silty clay loam is very productive, and the yields are much the same as on the silt loam.

The Chariton silt loam is an extensive terrace soil. It produces nearly as well as the Bremer silt loam and is especially suited to small grains.

The Waukesha very fine sandy loam occurs only along the Kansas River. It is a productive soil. The Waukesha silt loam is not extensive. It is handled much the same as the Muscatine silt loam.

The first-bottom soils are included in the Wabash and the Sarpy series.

The Wabash loam, silt loam, and silty clay loam occur as narrow strips along creeks. Where well drained, they give excellent yields. The Wabash clay occurs in level areas along Stranger Creek. It is a productive soil and is devoted to pasture and to corn and wheat growing.

The Sarpy very fine sandy loam and loam are developed along the Kansas and Missouri Rivers. They produce excellent yields, particularly of potatoes, corn, and hay crops. The Sarpy fine sandy loam is devoted chiefly to corn and alfalfa. The Sarpy clay is a strong soil, but is mostly in forest and used for grazing. The Sarpy fine sand is not extensively cultivated.

Riverwash includes small areas of coarse-textured material along the Kansas and Missouri Rivers. It is not cultivated, and where not barren supports a growth of willow or cottonwood sprouts and saplings.

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