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Soil Survey of Johnson County Kansas

By
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and
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Kansas Agricultural Experiment Station

Bureau of Chemistry and Soils
In cooperation
with the Kansas Agricultural Experiment Station

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SOIL SURVEY OF JOHNSON COUNTY, KANSAS

By E. W. KNOBEL, United States Department of Agriculture, in Charge, and R. H. DAVIS, Kansas Agricultural Experiment Station

COUNTY SURVEYED

Johnson County is in the eastern part of Kansas, on the Missouri-Kansas State line. (Fig. 1.) It includes an area of 473 square miles or 302,720 acres. Olathe, the county seat, is about 25 miles southwest of Kansas City.

Johnson County is in the south border zone of the glacial and loessial deposits in Kansas. A considerable part of the northeastern half of the county is covered by loess, and a few remnants of glacial deposits occur on the steep slopes bordering the Kansas River Valley, but the southern part of the county is covered by soils derived from limestones, shales, and sandstones of Paleozoic age.

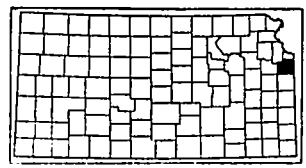

Figure 1.—Sketch map showing the location of Johnson County, Kans.

The relief of the county is the result of erosion on an originally nearly level plain. The Kansas River Valley, which forms one-half of the northern boundary, is the lowest part of the county. The small streams tributary to Kansas River have higher gradients than those flowing eastward or southward, hence the relief and dissection is more pronounced in the northern part of the county. The range in local relief is from 100 to 275 feet in the hilly areas. Along the larger streams in the eastern part of the county the range in relief is from 100 to 150 feet, and on the smooth uplands it is less than 100 feet.

Topographically Johnson County may be divided into three distinct divisions as follows: (1) The hilly areas along the larger streams, (2) the rolling or gently undulating uplands on the watersheds and along the small streams, and (3) the alluvial valleys including the terraces. The first division is best developed in the northwestern diagonal half of the county along Mill, Cedar, and Kill Creeks, which drain most of this part into Kansas River.

The alluvial lands are very smooth. They include a few square miles of the Kansas River flood plain and narrow strips along the larger creeks of the county. The second bottoms or terraces are from 10 to 25 feet above the adjoining first bottoms. They occur along Kill, Cedar, Mill, Tomahawk, Indian, and Martins Creeks and Blue River.

In 1825 General Clark selected lands in the area now included in Johnson County as a reservation for the Shawnee Indians, and in 1828 the first band was located there. Johnson County was organized in 1855 and named in honor of Rev. Thomas Johnson, a missionary to the Shawnee Indians, who located in the northern part of the county in the present Shawnee Township. The county seat was first located on the present site of Shawnee which at that time was called Gum Springs, but in the fall of 1858 Olathe became the county seat. In 1855 Kansas River constituted the entire northern boundary of the county, but the present boundary was established in 1859.

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According to the Federal census reports, the population of the county has increased from 16,853 in 1880 to 27,179 in 1930.[1] Olathe has 3,656 inhabitants, Spring Hill 566, Gardner 493, Shawnee 553, Lenexa 452, De Soto 384, and Edgerton 278. Most of the inhabitants are native-born whites. The foreign born came mainly from Germany, Sweden, Austria, England, and Denmark. There are a few colored people in the county.

The present railways in the county include lines of the Atchison, Topeka & Santa Fe, the St. Louis-San Francisco, and the Missouri Pacific. The Strang line, a trolley line, connects Kansas City and Olathe, and a trolley line extends into the county to Shawnee.

The public roads are in good condition. A combination concrete and brick road connects Olathe and Kansas City, Mo., and a solid concrete road connects Olathe and Spring Hill. A hard-surfaced road extends from Overland Park to the south county line, and another, from Lawrence, Kans., to Kansas City, Mo., passes through the northern part of the county. Other hard-surfaced roads in the northeastern part connect the towns near Kansas City. The county roads are well graded and passable by automobile throughout the year.

The public schools are good. During recent years a few consolidated schools have been built in towns or villages, and motor busses have been provided for the transportation of school children. Rural mail delivery serves all parts of the county.

CLIMATE

The climate of Johnson County, like that of all northeastern Kansas, is temperate and well suited to general grain and livestock farming. The winters are reasonably mild but are more or less changeable. Many days in January and February are bright and clear. However, snow flurries are common, and occasionally snow accumulates to a depth of 6 or 8 inches but remains only for a short time. Every few years the temperature falls to -15 or $-20°$ F. for a few days only. Such extremely low temperatures cause more or less winterkilling of fruit trees. The weather in spring is usually mild and cool, but the summers are fairly hot, with considerable variation in temperature, especially at night.

Approximately one-third of the annual precipitation falls during June, July, and August. Some injury to crops in the spring occasionally results from excessive rains, followed by dry weather, but the greater injury generally results from occasional droughty periods in midsummer, which may greatly reduce the yield of corn. Complete crop failures, however, are unknown.

The average date of the last killing frost at Olathe is April 21 and of the first is October 15, giving an average frost-free season of 176 days which is sufficient time to mature all the crops common to this region. It is also ample for growing a crop of cowpeas or soybeans following a crop of wheat or early potatoes. Injury from early fall frosts is negligible, but late spring frosts make such fruit crops as peaches and plums rather uncertain.

Table 1 shows the normal monthly, seasonal, and annual temperature and precipitation as recorded by the United States Weather Bureau station at Olathe. These data may be regarded as typical for the county, especially the uplands.

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

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Olathe, Kans.*

[Elevation, 1,032 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1901)	Total amount for the wettest year (1898)
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*
December	30.5	70	−10	1.49	1.97	2.30
January	30.1	72	−21	1.35	.23	4.75
February	31.5	78	−29	1.69	1.10	1.90
Winter	30.7	78	−29	4.53	3.30	8.95
March	44.7	92	−2	2.81	2.71	5.81
April	54.3	96	8	3.24	4.47	3.52
May	64.5	99	22	5.26	.44	11.88
Spring	54.5	99	−2	11.31	7.62	21.21
June	73.7	105	30	4.61	.38	4.81
July	78.0	110	45	4.20	3.12	5.93
August	77.1	111	44	4.61	2.32	5.27
Summer	76.3	111	30	13.42	5.80	16.01
September	69.2	107	30	4.25	4.16	4.19
October	58.2	94	15	2.39	.56	3.85
November	44.8	83	1	1.83	.97	1.68
Fall	57.4	107	1	8.47	5.69	9.72
Year	54.7	111	−29	37.73	22.41	55.89

AGRICULTURE

The earlier settlers of the county located in the valleys and along the margins between wooded and prairie land in order to be near water, wood, fish, and game. They fenced and cropped sufficient land to supply local needs, and grazed cattle on the open prairie, the cattle constituting their chief source of income. Lack of equipment, droughty years, and ravages of grasshoppers and chinch bugs were obstacles which had to be contended with in producing grain, and agricultural progress was necessarily slow.

Agricultural development, especially that which relates to crop production, has undergone a number of changes since the early days. Corn, wheat, oats, and potatoes have always been the most important crops grown. Several of the crops which were grown 50 or more years ago, including flax, hemp, tobacco, buckwheat, rice, millet, cotton, castor beans, and broomcorn, have been eliminated from the list of profitable crops, and at the present time it is very unusual to see even a small patch of any of them. Prior to 1873 only the spring varieties of wheat were grown, and the yields were not very satisfactory. In 1875 Mennonite farmers from Russia brought over some hard red winter wheat, and its immediate success induced the Department of Agriculture and other agencies to obtain additional importations. Thereafter the wheat-growing industry in Kansas rapidly increased. No timothy, alfalfa, cowpeas, soybeans, red clover,

sweetclover, or bluegrass were grown when the county was agriculturally new, and, prior to 1900, very little alfalfa or other leguminous crops were grown. During the last few years sweetclover has gained considerable recognition as a soil-improvement crop, especially in the Kansas River Valley. During the last few decades several other crops have made their appearance, including soybeans, cowpeas, English bluegrass, Sudan grass, feterita, and kafir. By comparing the average acreages of the most important crops during the years 1925, 1926, and 1927 with those of a corresponding number of years 50 years ago, it is noticed that the corn acreage has declined almost one-third, the wheat acreage is about four times greater, the oat acreage has almost doubled, whereas the potato acreage has remained practically the same.

The present agriculture consists of diversified farming. The main cash crop is wheat. A large proportion of the various other field crops are fed to livestock and converted into livestock or livestock products for sale. Truck and fruit growing are of considerable importance in the north and northeast parts of the county, owing to the large near-by market, Kansas City, and to the adaptability of such crops to the soils in this locality. In the Kansas River Valley potato growing is a specialized industry and the chief source of income, followed in importance by corn, wheat, melons, and turnips.

Tables 2 and 3 give statistical data, compiled by the Kansas State Board of Agriculture, relating to the agriculture in Johnson County in 1927 and 1928.

TABLE 2.—*Acreage, production, and value of field crops in Johnson County, Kans., in 1927 and 1928*

Crop	1927			1928		
	Acres	*Bushels*	*Value*	*Acres*	*Bushels*	*Value*
Corn	53,710	2,202,110	$1,519,456	62,969	2,329,853	$1,514,404
Wheat	39,640	554,960	654,853	30,147	542,646	667,454
Oats	26,154	758,466	318,555	23,096	646,688	271,609
Rye	317	4,755	4,517	302	6,040	5,617
Flax	139	834	1,626	60	540	972
Potatoes	2,244	327,624	255,547	2,359	436,415	148,381
Sweetpotatoes	78	8,760	7,008	124	19,840	17,459
Soybeans for grain	242	2,420	4,719	183	1,830	4,026
		Tons			*Tons*	
Soybeans for hay	108	212	1,781	57	103	958
Cowpeas for hay and grain	37	149	689	47	211	667
		Gallons			*Gallons*	
Sorgo for sirup	31	1,550	1,472	36	2,880	2,938
		Tons			*Tons*	
Sorghum for hay	391	2,346	9,384	296	1,480	4,588
Kafir for hay	70	245	1,102	43	129	413
		Bushels			*Bushels*	
Kafir for grain	1,553	62,120	39,135	1,455	48,015	31,209
		Tons			*Tons*	
Sudan grass	239	836	4,180	114	262	1,257
Alfalfa	8,642	26,790	259,863	7,166	20,781	311,715
Timothy	7,628	12,205	87,876	7,446	9,680	79,376
Red clover	4,081	7,754	58,155	4,132	6,198	59,191
Timothy and clover	3,073	5,224	42,837	3,831	6,130	52,411
Sweetclover	1,216	3,405	15,322	956	1,912	10,516
Other tame grasses	135	180	1,417	53	69	648
Prairie hay	2,507	3,008	15,942	2,046	2,455	13,502
Total			3,305,436			3,199,311

TABLE 3.—*Quantity and value of livestock products and livestock in Johnson County, Kans., in 1927 and 1928*

Livestock products	1927		1928	
	Quantity	Value	Quantity	Value
	Pounds	*Dollars*	*Pounds*	*Dollars*
Animals sold and slaughtered	----------	1,133,800	----------	1,050,876
Poultry and eggs sold	----------	365,090	----------	250,027
Wool clipped	28,927	8,678	45,040	16,240
Wool sold	----------	1,190	----------	2,910
Cheese sold	4,816	722	1,167	12,837
Butter sold	422,717	175,215	582,480	244,293
Condensed milk and ice cream manufactured	----------	16,650	----------	17,529
Milk sold	----------	509,957	----------	1,319,662
Honey and beeswax sold	520	93	8,112	1,379
Total	----------	2,211,395	----------	2,915,753

Livestock	1927		1928	
	Number	Value	Number	Value
		Dollars		*Dollars*
Horses	6,740	370,700	6,833	375,815
Mules	2,167	164,692	1,982	148,650
Milk cows	10,501	714,068	11,523	956,409
Other cattle	9,180	408,510	10,685	619,730
Sheep	3,909	35,963	5,630	59,115
Swine	22,893	367,433	28,136	455,803
Total	----------	2,061,366	----------	2,615,522

Corn is by far the most important crop grown, and at the present time the yearly corn acreage is about two and one-half times as great as that of wheat which ranks second in importance. In the earlier days the corn acreage was several times as great as that of wheat, owing to the high yields and the desirability of corn for the fattening of cattle, which was one of the chief sources of income. The gradual decline in yields, the substitution of other crops, and the undesirable effects of erosion on certain soils have tended to reduce the acreage in corn. The average yield of corn, based on yearly average yields during the 14-year period from 1915 to 1928, inclusive, was 32.1 bushels an acre, with fluctuations in average yearly yields from 19 to 41 bushels an acre.[2] Owing to the uncertainty of rainfall in late summer, after the tasseling period, corn can not be depended on to produce high yields every year. The years 1927 and 1928 were exceptionally favorable for corn, and the average yield was high. The corn crop is utilized on the farm as feed for cattle, hogs, sheep, poultry, and work animals. Some corn is shucked and cribbed, some cut for silage, some cut and shocked for fodder, and on some farms a part of the crop is hogged down. Some farmers grow a crop of cowpeas or soybeans between the corn rows to provide extra forage as well as to increase the nitrogen content in the soil. A comparatively small amount of corn is sold on the ear or shelled. Pride of Saline, Boone County White, Kansas Sunflower, Midland Yellow Dent, and Reid Yellow Dent are the varieties most commonly grown.

[2] Average yields computed from the biennial reports of the Kansas State Board of Agriculture.

Although wheat is common in all parts of the county, it is grown more extensively in the central, western, and southwestern parts. Its average yield from 1915 to 1928 was 17.3 bushels an acre. It is all harvested with the binder and shocked. Some is stacked, but most of the crop is threshed directly from the shock. A large percentage of the grain is sold immediately after threshing at local elevators, but a few farmers store their grain in order to obtain higher prices. The principal varieties of wheat grown are Harvest Queen, Blackhull, and Fultz.

Oats, ranking third in importance, are grown primarily as feed for work animals and to some extent as a nurse crop for clover, timothy, and alfalfa. The average acre yield for the 14-year period, 1915 to 1928, was 29.9 bushels. Oat yields are more variable than those of wheat, the higher yields ordinarily being obtained when the crop is seeded as early as possible in the spring. Very little effort is made to control smut, although this disease sometimes reduces yields from 10 to 15 per cent. Most of the oats are grown as a step in the rotation between corn, wheat, or alfalfa. The leading varieties are Kanota, Red Texas (Red Rustproof), and Kherson, the first two being most extensively grown.

Potatoes rank fourth in value as a field crop, but the commercial production of this crop is confined mainly to the Kansas River Valley, where more than 1,700 acres are planted annually. The potatoes are graded before being shipped to market. The culls are bought at very nominal prices by Kansas City dealers and retailed to the poorer people. About 90 per cent of the planted tubers are treated with hot formaldehyde to control Rhizoctonia. Irish Cobbler and Early Ohio are the principal potato varieties. The average yield for the county during the last 14-year period was 79.2 bushels an acre.

Alfalfa ranks fourth in acreage and fifth in value as a field crop. This crop is rapidly gaining in favor, but in the past it has not been thoroughly understood by local farmers, and its acreage and production have been small. Many of the upland soils suitable for alfalfa production are not only deficient in lime but also in available phosphorus. Proper liming of adaptable soils and the application of phosphatic fertilizers ordinarily insure excellent stands unless the season is unfavorable after the seeding of this crop. Crushed limestone is generally applied at the rate of 1½ to 3 tons to the acre, depending on the acidity of the soil, an average of around 2 tons generally being sufficient to supply the needs of the alfalfa crop. Inoculation of the alfalfa seed is an added assurance of a successful stand. This crop is not adapted to the heavy claypan soils which are common in the western part of the county, but with proper care and soil treatment alfalfa is successful especially on soils having permeable and friable subsoils and even on those with moderately heavy subsoils. Ordinarily three or four cuttings are obtained, each of which yields from three-fourths to more than 1 ton of hay to the acre. The average acre yield for the 13-year period prior to 1928 was 2.8 tons a season. Kansas common and Grimm are two of the best varieties of alfalfa adapted to this locality.

Other tame-hay crops are timothy, red clover, and timothy and red clover mixed, all of which are almost equal in acreage, production, and value. The acreage of timothy, however, is on the decline, owing to the greater value of other crops for rotation purposes. Timothy is grown mainly for seed and as feed for horses. Some of

the hay is baled and marketed. Red clover is used extensively as hay for dairy cattle, and it is also considered one of the best soil builders, which is one of the principal reasons for its extensive production. The first crop is usually cut for hay and the second either turned under as green manure or utilized as a seed crop. The seed crop is often of more value than the hay crop, owing to the scarcity of red clover seed in recent years. For all-round hay purposes timothy and clover mixed is very desirable, and ordinarily this combination is more dependable in producing good stands. Clover alone is usually sown with either oats or wheat as a nurse crop. A few farmers apply superphosphate (acid phosphate) in order to increase the grain yields and to insure a more rapid growth of the clover. The successful production of red clover, as well as of alfalfa, is limited to certain soils, depending on the degree of acidity, unless the acid condition is corrected at seeding time.

Sweetclover is gaining in importance both as a pasture crop and as a soil builder. As the practice of applying crushed limestone to soils becomes more common, the sweetclover acreage, like that of alfalfa, will probably materially increase. It is an excellent pasture crop for cattle and hogs, but its greater value is in supplying organic matter and nitrogen to soils which have been heavily cropped. Its vigorous root system is also a desirable asset because the roots penetrate the stiffer subsoils and make them more permeable to rapid movement of moisture. The use of sweetclover, as a source of organic matter and nitrogen for the usual succeeding crop of potatoes, is rapidly increasing in the Kansas River Valley.

Soybeans and cowpeas are grown to a small extent as soil-improvement crops. When plowed under while green, they have the same effect as sweetclover, red clover, and alfalfa. They are also of value as a seed and hay crop.

Kafir, feterita, Sudan grass, sorghum for hay and stover, and English bluegrass are grown in a small way, but their acreage fluctuates considerably from year to year. English bluegrass is grown mainly for seed, the greater part of which is exported to Europe.

Trucking is carried on to some extent in the Kansas River Valley, and to greater extent in the uplands in the northeastern part of the county. Grapes, tomatoes, asparagus, sweet corn, beets, carrots, spinach, and numerous early vegetables are grown for the Kansas City market, and melons, turnips, and potatoes are the main truck crops. According to the 1926-27 biennial report of the Kansas State Horticultural Society there were 1,349 acres in commercial gardens in 1926, the value of the crops amounting to $168,625. Home gardens totaled 173 acres, with products valued at $27,625.

Between 1880 and 1900 there were a number of commercial orchards in the county, but their irregularity in bearing and occasional late spring frosts have tended to discourage the planting of orchards other than for home needs during the last two or three decades. Most farmers have enough orchard fruits for home use, with some to sell. The most common varieties of apples are Jonathan, King David, Grimes Golden, Ben Davis, York Imperial, and Winesap. The 1926-27 biennial report of the Kansas State Horticultural Society reports 16,818 apple, 3,588 pear, 10,400 peach, 4,242 plum, 10,514 cherry, 100 quince, and 426 apricot trees of bearing age, and 17,211, 1,724, 9,180, 2,103, 5,190, 79, and 368 trees, respectively, of nonbearing age. The value of all fruits in 1926 was $71,654.

According to the biennial report of the State board of agriculture for the year 1926, the combined value of all field crops was $2,283,356, of livestock and livestock products sold, $1,970,297, and of all livestock on the farms, $1,885,896. From these figures it is apparent that the livestock industry occupies a very important place.

Hog raising provides considerable income. A large part of the corn crop is utilized in fattening hogs for market. During the spring and summer the hogs are allowed to graze mainly on bluegrass pasture and to some extent on sweetclover, red clover, alfalfa, soybeans, and cowpeas, on farms where these crops are grown. Most of the hogs are of the Duroc-Jersey and Poland China breeds, and a small percentage are of spotted Poland China, Hampshire, Chester White, and mixed breeds.

The feeding and breeding of beef cattle is practiced to a considerable extent. The animals for fattening are raised on the farm, or feeder cattle are bought on the Kansas City market and fattened on the farm. A few farmers specialize in purebred herds, but this phase of the cattle industry is rather limited.

Dairying is becoming a rather important industry, owing to the near-by good market for whole and bottled milk and to the development of milk routes which facilitate economical and prompt distribution. A creamery is located at Olathe. The large acreage of bluegrass pasture available, the rapid increase in the production of alfalfa and sweetclover as feed crops, the abundance of good water, and the nearness to market should have a tendency to greatly increase this industry. In 1928 there were about 175 dairy herds kept for supplying whole and bottled milk for the Kansas City market. The Holstein and Jersey breeds are most popular. There were 853 cream separators and 127 silos in the county in 1926, according to the report of the State board of agriculture.

The majority of farmers own several work horses or mules to assist in performing general farming operations, but tractors play an important part. In 1926 there were 274 tractors in the county, or an increase of 43 over the number in 1925.

Sheep are not numerous, as indicated in Table 3, and this branch of the livestock industry is pursued by only a few farmers. Some sheep are raised on the farm, but the greater number are bought on the Kansas City market and fattened on local crops.

Poultry is raised on practically all farms, for local consumption and for market, and the income derived from this source is indicated in Table 3.

Livestock and livestock products are marketed by the farmers themselves, mainly by truck to Kansas City. The hard-surfaced highways afford convenient auto and truck transportation to the majority of the farmers.

The average farm is well improved and equipped. Most farmsteads have modern homes, bluegrass lawns, and ample shade trees. Substantial barns and other buildings are common, and some farms have one or more silos and windmills. The farms are fenced with well-constructed fences. Farm machinery of various kinds is plentiful, and a large percentage of farmers keep it under shelter. The improvements are poor on farms consisting of poor types of soil. More than 95 per cent of the abandoned farmhouses in the county are in the western three tiers of sections, where the land is less productive.

Farm labor is largely American. Most farms are operated without the use of hired labor except during harvesting.

In the trucking section in the northeastern part of the county and in the Kansas River Valley the farms are smaller than in the central, southern, and western parts of the county. The average size of farms as reported by the 1930 census, is 114 acres. The assessed value of farm land is steadily increasing, the average value, including buildings, being $135.84 an acre.

The percentage of farms operated by owners has remained fairly constant since 1900. In 1930, 61.7 per cent of the farms were operated by owners, 36.9 per cent by tenants, and 1.4 per cent by managers.

The value of lime for alfalfa and clover production is realized by many of the farmers, and the amount used is increasing at a rapid rate. Prior to 1923 little lime had been used in the county. In 1923, 50 tons were used; in 1924, 560 tons; in 1925, 1,250 tons; in 1926, 3,050 tons; in 1927, 2,175 tons; and in 1928, 3,551 tons.[3] Much of the limestone is shipped into the county. Three portable pulverizers were available in the county in 1928, and limestone was ground on individual farms at a cost of $1.50 a ton. Most of the local limestone tests from 95 to 97 per cent carbonate. In 1928 the number of acres of alfalfa sown on limed ground was 2,224, of sweetclover 286, of soybeans 110, of hay 124, and of corn 1,522. Lime has proved beneficial on all the upland soils of the county. The Knox and Clinton soils, however, require less lime than the dark-colored soils, such as the Marshall, Labette, Bates, and Summit.

Practically no commercial fertilizer had been used until very recently. Its use during 1927 and 1928 proved highly successful. However, during those years the precipitation during the growing season was greater than in average years. Phosphate fertilizers increased alfalfa yields as much as 1½ tons an acre, wheat yields from 6 to 8 bushels, oat and barley yields from 8 to 10 bushels, and corn from 5 to 15 bushels. About 60 tons of commercial fertilizer, composed mainly of superphosphate and steamed bone meal, were used in 1927 and 140 tons in 1928. Ordinarily the available barnyard manure is applied to land planted to corn. A few farmers who are engaged in intensive trucking apply from 15 to 25 tons of manure to the acre. On the brown upland soils, mainly the Knox soils and Clinton silt loam, a small quantity of nitrogenous fertilizers, such as ammonium sulphate and sodium nitrate, could be used advantageously for fruits and vegetables. In general, the Marshall and Labette soils are fairly well supplied with phosphorus and potash, and up to this time very little return has been realized by the application of these materials. The heavier Summit and Parsons soils respond best to applications of phosphatic fertilizers.

In the northeastern part of the county and in the Kansas River Valley some farmers use green-manure crops, such as cowpeas, soybeans, sweetclover, or red clover, in order to increase the productiveness of their soils. The use of these legumes has proved profitable and will very likely become more general in the future. In the south-central and western parts, where the subsoils are rather heavy, it is quite probable that an acre application of 100 or 125 pounds of superphosphate for wheat would give excellent results.

[3] Data obtained from office of county demonstration agent.

Tillage operations vary to some extent in different parts of the county. Both fall and spring plowing are practiced. The depth of plowing on upland soils is about 6 inches for corn and often less for wheat. On the sandy Kansas River Valley soils, the depth of plowing for wheat is 4 or 5 inches, for corn from 6 to 8 inches, and for potatoes from 8 to 10 inches. Corn is planted both by the checkrow and listing methods. On soils having loose friable subsoils, such as those in the northeastern part of the county, and on the alluvial soils the corn is usually listed, and on the soils having heavier subsoils it is usually checkrowed. Most of the alfalfa is seeded in August or early September, but some farmers prefer to seed in the spring with a nurse crop of wheat or oats.

In general, no very definite cropping system in which a legume is grown every three to five years has been followed. Most farms have been almost continually cropped to either wheat or corn or both, and this practice has resulted not only in the depletion of nitrogen, phosphorus, and other plant nutrients but also in the more disastrous effects of erosion on the sloping soils. In the northeastern part of the county alfalfa has been grown by some farmers rather consistently or as long as satisfactory yields were produced, but on few farms is it grown on the various fields with any regularity. Red clover is more commonly and consistently grown in the cropping systems in the northeastern part of the county.

Erosion is an important problem on sloping land, at least one-half of the county being subject to more or less erosional wastage on fields under cultivation. Soils having friable or moderately friable subsoils are the most susceptible to erosion, but these soils can withstand more erosion without serious impairment of the tilth than can soils with heavy or claypan subsoils. The loss of the loose silty surface soil with its valuable supply of organic matter and nitrogen is most serious, however, on either class of land. The almost continual cropping of the sloping soils to corn and small grain has greatly facilitated erosional activity, because the mean annual precipitation of nearly 38 inches is so distributed that 18.68 inches falls during May, June, July, and August, at which time all corn soils are in a clean state of cultivation. The prevailing practice of planting corn without regard to slope has greatly accelerated erosion. Although some fields in the northern part of the county have been abandoned, most of the severely eroded fields are still under cultivation, and a number will probably revert to pasture or brush land unless something be done to retard erosion. The gradual elimination of the mellow topsoil, with its supply of organic matter, and the mixing of the heavier underlying raw subsoil material causes the fields to be less permeable to moisture and crop roots, less absorptive of moisture, far less productive, and the tilth is greatly impaired. To rebuild such land takes several years and is expensive. Heavy applications of manure or the frequent turning under of leguminous crops is necessary, but unless provision is made to check erosion other efforts toward soil improvement will ordinarily prove fruitless.

The construction of terraces is a dependable means of preventing the disastrous effects of erosion on land continually cropped. At the time of the survey (1928) only two farmers had adopted the terracing method so common over the Gulf States. The broad Mangum terrace (pl. 1, A) is probably the best suited to the majority of fields in

need of terracing. By this method water flowing over a terraced field has to follow the slow gradients of several terraces, thereby depositing most of the silt that may have been removed by erosion. Each terrace receives only the precipitation between it and the upper one so that only a comparatively small amount of run-off is obstructed by each terrace. Destructive gullying is prevented so long as the terraces are properly maintained, a much higher acreage yield is obtained indefinitely, and the land has a higher value. In a number of counties, much farther north than Johnson County, active terracing has been under way for several years, and this method of maintaining the productiveness of the land has proved highly successful.

A complete system of erosion control should include a cropping system that will keep the land covered with a growing crop a large part of the time, and it should be remembered that small grain and sod legumes like clover and alfalfa are much more effective than cultivated crops and should always be included in the rotation if erosion is to be controlled. The use of contour farming when the land is in row crops will also add much to the effectiveness of terraces and reduce erosion to a minimum throughout the whole rotation.

Land values have an unusually wide range. The steep rocky timbered upland adjoining Kansas River and other inland streams is the lowest in value because it is nonarable and is utilized mainly for grazing purposes. The land of highest value is in the northeastern part of the county in close proximity to Kansas City, where land values are speculative rather than agricultural. The dark-brown soils with very friable subsoils, such as the Marshall soils, are of the highest agricultural value. At the time of this survey, land values ranged from $250 an acre within a few miles of Lenexa, to $600 or $800 near Shawnee, and to as high as $2,500 or $3,000 or more an acre in the extreme northeastern part of the county where the land was being rapidly utilized for home sites in the more beautiful residential districts of Kansas City. Isolated areas of the steep, rocky, timbered land can be bought for $20 or $25 an acre, but in a number of places artificial lakes, hard-surfaced highways, and other improvements enhance the value of such land.

The price of tillable land ordinarily ranges from about $50 to $200 an acre. The most important farming lands of the county, which include the Summit and Labette soils, average about the same in their agricultural worth, but current prices ordinarily range from about $75 to $200 an acre, depending on improvements and distance to highways and towns. The lowest-priced tillable land consists of the Parsons soils which occur in the western part of the county. The Bates soils are next lowest but the value of areas having gentle slopes closely approaches that of the Summit and Labette soils. Farms including light-colored upland soils, such as the Clinton and Knox, are about equal in agricultural value, but ordinarily bring less than those including Marshall, Summit, and Labette soils. Several areas near towns are held at high prices because of their speculative value. The alluvial soils of the Kansas River Valley command from about $100 to several hundred dollars an acre depending on elevation above the normal river level and distance from shipping points. Most of the other first-bottom areas are not so valuable, but they compare favorably with the Summit and Labette soils of the upland.

SOILS AND CROPS

The chief industries of Johnson County are agricultural. The soil is the only natural resource in the county, and the close proximity to Kansas City is favorable to the production not only of the usual hay and grain crops but also of various truck and fruit crops. Approximately 92 per cent of the area of the county is topographically suitable for cultivation. Trucking is more important in the northeastern part than elsewhere because of the nearness to Kansas City and the adaptability of the soils to such crops. In the central and southern parts corn, small grains, and hay crops are the more important, and small grains predominate in the western part. On the alluvial soils of the Kansas River Valley large quantities of potatoes and melons are produced, as well as corn and hay crops.

For convenience of discussion the upland soils of Johnson County can be broadly grouped into light-colored and dark-colored soils. The light-colored soils occur along both sides of the main stream valleys occupying a belt of rolling or steep land ranging from 2 miles to less than one-half mile in width. The dark-colored soils are by far the more important. They occur in general on smooth areas throughout the county. They have developed under the influence of grass vegetation, the continuous decay of which, mainly the roots, has favored the accumulation of large quantities of organic matter.

The high organic-matter content has several beneficial effects. It assists the soil in absorbing the sun's heat and in maintaining a uniform temperature; it greatly increases the water-holding capacity and also makes the soil more retentive of moisture; it retards destructive erosion on the steeper slopes; it materially increases the stability of the mineral soil particles and helps to maintain a desirable tilth; and it is the chief source of nitrogen which is one of the most important plant foods for growing crops.

Dark-colored upland soils having deep surface soils not only contain a high proportion of organic matter but have also a very loose granular, crumb structure which facilitates penetration of water and the maximum feeding range for crop roots. The structure allows free aeration, which, in combination with the soil moisture, changes the raw organic and mineral constituents into more available plant food. A large part of the soils of this group, therefore, is well adapted to the production of all the general farm crops, such as corn, small grains, legumes, and orchard crops. Inasmuch as practically all these soils are very similar in outward appearance their chief limitations on various crops and crop yields depend on the depth to the underlying subsoil and to its intractability.

Alluvial soils may also be divided into light-colored and dark-colored soils. However, the color differences of these soils are less pronounced, being due mainly to the character and source of the soil material, the darker-colored soils having their source in the dark-colored upland soils.

The annual precipitation has been sufficient to leach the lime in the soil profile to a depth ranging from 3 to 6 feet. The light-colored upland soils contain lime at various depths, but lime is consistently nearer the surface than in the dark-colored upland soils, except those with claypan subsoils. The run-off on the steep slopes is not only greater but the amount of rainfall is comparatively less, owing to the

greater linear space it covers. Soils with claypan subsoils contain lime at a slighter depth because the claypan serves as a protection against deep leaching. The light-colored alluvial soils, notwithstanding their sandiness, contain lime nearer the surface than the dark-colored alluvial soils because they are composed of sediments from regions further west, which are higher in lime carbonate.

The smooth surface on which the dark-colored upland soils lie has allowed the cultivation of practically the whole area, though approximately 10 per cent is in permanent pasture. On the other hand, much of the area occupied by the light-colored soils is so hilly or rocky that a large percentage is nonarable. The cultivable land is adapted to as wide a range of crops as that of the dark-colored soils. However, the lower content of organic matter renders certain kinds of crops better adapted and others not so well adapted.

All the field crops common to the region are grown to greater or less extent on both upland and alluvial soils, but the yields differ. The net profit derived from producing any given crop, assuming the farmer to be efficient, depends on the market price, accessibility to markets, climatic influence, and productivity of the soil on which the crop is grown. Most farmers strive to grow the crops which, according to past experience, give the largest returns on the investment. Corn, the most extensively grown crop in the county, is better adapted to, and is grown more extensively on, the dark-colored upland and dark alluvial soils than on the lighter-colored soils because higher yields are obtained. An exception, however, is noted in the western part of the county where claypan soils exist. Wheat and oat yields, although not so high on the light-colored as on the dark-colored upland soils, are relatively higher than corn because these crops do not require soils so high in nitrogen, mature earlier, and are less susceptible to drought than corn. Alfalfa is successfully grown on both light-colored and dark-colored upland and alluvial soils, other than those having claypans, but it usually returns better yields on the dark alluvial soils than on the dark upland soils, probably because of better moisture supply. The crop is more successfully grown on the dark-colored upland soils than on the light-colored ones because the underlying substratum has a higher and more abundant water supply than land on the narrow ridges and steeper slopes of the light-colored soils. Liming is necessary on the soils of both groups but not on the alluvial soils of the Kansas River Valley. Orchard crops, grapes, and berries are better adapted to light-colored upland soils because these crops do not require a high organic-matter content but do require a friable, permeable subsoil.

The groups of light-colored and dark-colored soils are each made up of several members, known as soil types, which are separated on the basis of various characteristics. Soils having the same general profile characteristics, which include color, origin, thickness of layers, degree of plasticity or friability, percentage of lime, and other features, are differentiated into soil series and named from some town or locality where these soils were first identified.

Inasmuch as several soils have similar characteristics and also produce very similar crop yields, the soils of Johnson County may be divided into six groups, based on soil differences that have a marked effect on the crop-producing capacity of the soils. The groups have, therefore, a similar agricultural value as determined by the type of

farming to which they are adapted, the crops that may be grown, and the cultural methods and fertilization necessary for successful farming.

These groups may be briefly named and described as follows: (1) Dark-brown soils with friable subsoils; (2) dark-brown, brown, or reddish-brown soils with moderately friable subsoils; (3) dark-brown soils with heavy subsoils; (4) grayish-brown soils with claypan subsoils; (5) light-colored soils with friable or moderately heavy subsoils; and (6) undifferentiated soils of rough stony areas.

In the following pages of this report the soils of Johnson County are described in detail, and their agricultural adaptations are discussed. Their distribution is shown on the accompanying soil map, and their acreage and proportionate extent are given in Table 4.

TABLE 4.—*Acreage and proportionate extent of the soils mapped in Johnson County, Kans.*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Marshall silt loam	20,352	6.5	Summit silty clay loam	7,296	2.4
Labette silt loam	84,800	28.0	Summit silty clay	832	.3
Summit silt loam	54,848	18.1	Parsons silt loam	25,472	8.4
Waukesha silt loam	2,880	1.0	Knox silt loam	3,072	1.0
Waukesha silty clay loam	384	.1	Knox silty clay loam	448	.2
Verdigris silt loam	13,760	4.6	Clinton silt loam	8,384	2.8
Verdigris silty clay loam	448	.2	Elk silt loam	2,816	.9
Labette silty clay loam	7,104	2.4	Verdigris very fine sandy loam	4,288	1.4
Bates loam	2,944	1.0	Summit, Labette, and Newtonia stony silty clay loams, undifferentiated	28,804	9.5
Bates silt loam	6,976	2.3			
Riverton loam	896	.3			
Newtonia silt loam	128	.1			
Summit silt loam, heavy phase	21,824	7.2	Total	302,720	
Summit silt loam, flat phase	3,904	1.3			

DARK-BROWN SOILS WITH FRIABLE SUBSOILS

This group includes seven soils of the uplands and well-drained terraces—Marshall silt loam, Labette silt loam, Summit silt loam, Waukesha silt loam, Waukesha silty clay loam, Verdigris silt loam, and Verdigris silty clay loam. The upland soils of the group occur both on slopes and on broad ridges but the surface, in general, is gently undulating. The terrace soils are nearly flat or gently sloping except where erosion has produced an undulating surface. The soils of this group belong to five distinct series based mainly on minor technical differences, but they have certain common characteristics that give to them a similar capacity to produce crops.

The characteristics of the soils of this group are such as are favorable to the growth of a wide range of crops. The deep surface soils have accumulated a large amount of organic matter and the smooth surface has prevented the thinning of the dark-colored surface soils by erosion. The loose granular, or crumb, structure insures a high moisture-absorbing capacity. The friable permeable character of the subsoils allows free and unobstructed root development of both grain and orchard crops, as well as free movement of moisture. Although tests show that lime carbonate is present in very negligible quantities to a depth of 4 or 5 feet, it is present in sufficient quantities to allow the growth of clovers and alfalfa without liming, though treatment with lime insures not only heavier yields but the stands endure for longer periods. Therefore, the natural characteristics of these soils

favor the highest yields for the county of all crops usually grown, including corn, small grains, and all kinds of truck, floral, and fruit crops, together with orchard crops consisting mainly of apples and pears.

Corn is the chief crop grown. It is better adapted to these soils than to other soils of the county, because these soils are more drought resistant than other upland soils. Should the season be favorable the yield is high because, as previously stated, all the characteristics of these soils are such as to favor high crop yields. Yields of wheat and other small grains, although often high, are not so consistently high as corn yields. Alfalfa and red clover are grown with excellent results. (Pl. 1, B.) About four cuttings of alfalfa are obtained, and yields range from 2½ to 4 tons an acre. Corn yields ordinarily range from about 35 to 50 bushels an acre, wheat from 15 to 24 bushels, and oats from 25 to 35 bushels.

Marshall silt loam.—Marshall silt loam (pl. 2, A) has a very dark-brown topsoil about 14 inches thick, which is loose, mellow, very silty, and of high organic-matter content. It is underlain by a 4 to 6 inch transitional layer which grades into lighter-brown slightly heavier soil material. The upper part of the subsoil, beginning at a depth ranging from 18 to 22 inches, is light-brown silty clay loam, the color gradually merging into lighter shades. The lower part of the subsoil at a depth ranging from 28 to 34 inches becomes lighter in texture, approximating heavy silt loam, and it is grayish brown or yellowish brown.

On the older sloping cultivated fields the surface soil is brown instead of dark brown, indicating that a considerable part of the topsoil has been removed by erosion. Ordinarily the texture of the surface soil is somewhat heavier, in most places grading from heavy silt loam to silty clay loam.

Trucking is gaining in importance on Marshall silt loam. On this soil are located several small rapidly growing towns, and land values are so high that, in order to make interest on the land investment, intensive trucking is necessary. Sweetpotatoes, strawberries, cabbage, tomatoes, spinach, potatoes, celery, beets, and other vegetables, as well as vineyards, afford the chief sources of revenue. Several truck gardeners obtain manure from the packing plants at Kansas City and spread it on their land in applications ranging from 10 to 20 tons an acre in order to obtain the largest possible yields. Although this soil is well adapted to orchard fruits, chiefly apples, cherries, and pears, only a few very small apple orchards occur on it because of the high price of land and the necessary time required for orchards to reach bearing size.

Labette silt loam.—To a depth ranging from 2 to 3 feet Labette silt loam has been more or less colored by organic matter. The lower part of the layer becomes gradually lighter in color and at the depth mentioned changes to brown or reddish brown, depending on the thoroughness of subsoil drainage. In no place, however, is the surface soil or subsoil poorly drained. Some segregation of iron oxide into spots takes place in the subsoil.

Erosion may become a serious problem on this soil, and because of this the prosperity of the inhabitants depends to an important extent on the effective prevention of erosion.

In the average cultivated field the topsoil of Labette silt loam consists of brown or faint reddish-brown silt loam from 8 to 12 inches thick. The very few virgin areas, however, have a dark-brown crumbly silt loam surface soil about 18 inches thick. This indicates that a very liberal quantity of organic matter was present prior to cultivation, but intensive cultivation has increased erosional activity to such an extent that the surface soil is thinner than formerly.

Below the topsoil and continuing to a depth of about 20 inches the material is light-brown silty clay loam, and beneath this the material is moderately friable pale reddish-brown silty clay which contains numerous rust-brown or reddish-brown spots and is mottled with gray, yellow, and red. The lower subsoil layer, below a depth ranging from 28 to 32 inches, consists of moderately friable silty clay containing a higher percentage of gray material and less red than the layers above.

In Table 5 are shown the results of mechanical analyses of samples of the surface soil, subsurface soil, and subsoil of Labette silt loam.

TABLE 5.—*Mechanical analyses of Labette silt loam*

No.	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*
382236	Surface soil, 0 to 12 inches	0.0	0.1	0.1	3.6	2.8	58.1	35.4
382237	Subsurface soil, 12 to 18 inches	.1	.1	.2	3.8	3.2	53.5	39.1
382238	Subsoil, 18 to 24 inches	.1	.4	.4	5.7	4.8	45.9	42.6
382239	Subsoil, 24 to 48 inches	.3	.2	.3	8.2	7.6	38.7	44.6

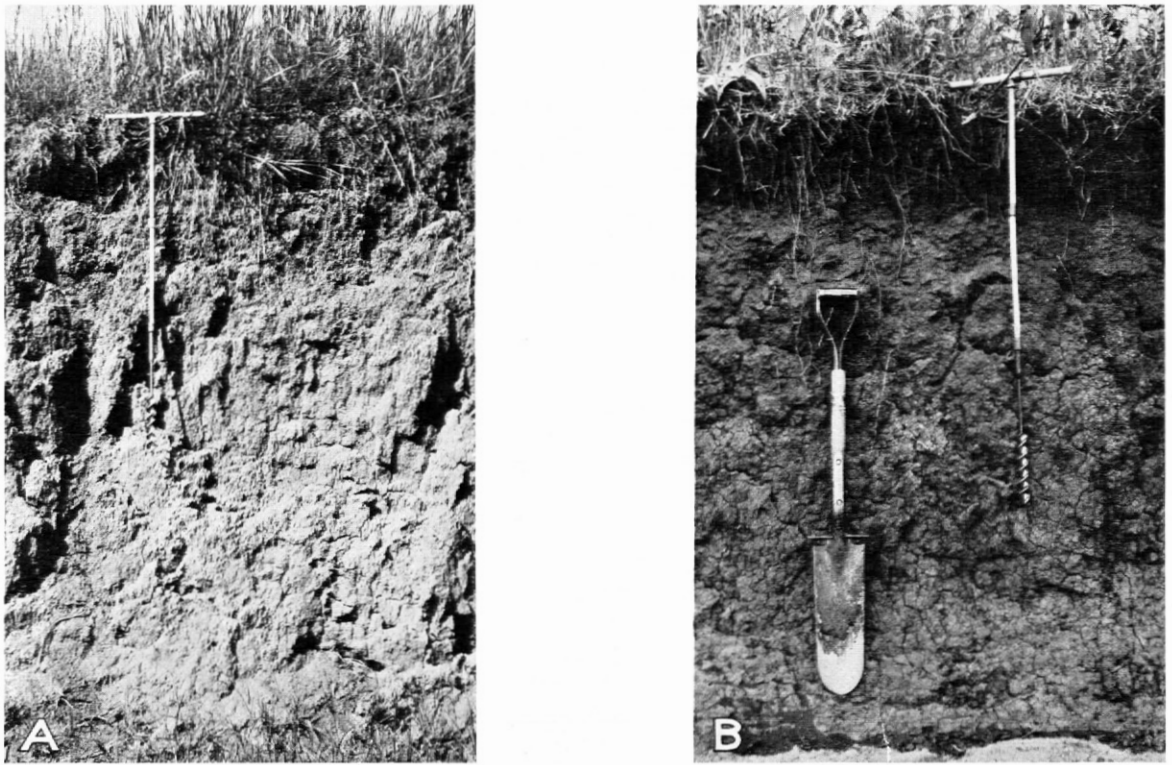
Summit silt loam.— Summit silt loam has a mellow dark grayish-black or dark grayish-brown surface soil to a depth of about 12 inches, below which a gradational layer merging into heavier and stiffer material occurs. (Pl. 2, B.) The subsoil, beginning at a depth of about 15 inches consists of dull brownish-gray heavy plastic clay which grades into yellowish-gray or olive-gray clay. The lower subsoil layer, at a depth ranging from 26 inches to 4 feet is yellowish-gray or light olive-gray clay which is less plastic than the clay in the overlying layer but which contains rather conspicuous spots of rust-brown stains and some small concretions of iron oxide. Concretions of calcium carbonate are common, in most places occurring below a depth ranging from 26 to 40 inches. The calcium carbonate has been leached from the layers lying above this depth.

Table 6 shows the mechanical composition of several layers of Summit silt loam. This soil is even heavier than Labette silt loam but for the reasons given under the description of the Labette soil on page 29, Summit silt loam as mapped in the field has been continued as such.

TABLE 6.—*Mechanical analyses of Summit silt loam*

No.	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*
382240	Surface soil 0 to 12 inches	0.1	0.2	0.4	0.8	1.8	63.8	32.9
382241	Subsurface soil, 12 to 16 inches	.0	.3	.5	.8	1.4	55.7	41.3
382242	Subsoil, 16 to 26 inches	.1	.4	.5	.8	1.3	43.2	53.7
382243	Subsoil, 26 to 34 inches	.2	.6	.3	.5	1.5	46.9	50.0
382244	Subsoil, 34 to 50 inches	.2	.4	.2	.6	8.7	52.1	37.9

A, Broad Mangum terrace under construction; B, gently undulating relief characteristic of Marshall silt loam. Heavy stand of alfalfa ready for second cutting; C, characteristic fine-grained sandstone material underlying the Bates soils



A, Weathered virgin profile of Marshall silt loam. The absence of cracks indicates a high degree of friability; B, weathered profile of Summit silt loam

Waukesha silt loam.—Waukesha silt loam occupies well-drained second bottoms, and in most places the soil closely resembles Summit silt loam.

In most places the surface soil consists of dark-brown loose silt loam from 10 to 14 inches thick which grades into heavy silt loam or silty clay loam of a slightly lighter tint. At a depth ranging from 15 to 18 inches the subsoil is brown or light-brown friable silty clay loam which continues downward to a depth ranging from 36 to 45 inches or deeper with very little change.

In some localities the surface soil is dark grayish-brown or grayish-black silt loam about 14 inches thick. It is underlain by very dark gray or grayish-black silty clay loam which gradually increases in heaviness or clay content to a depth of about 2 feet where it is silty clay in texture. At a depth of 40 or more inches the material is olive-gray silty clay.

Corn, wheat, oats, and alfalfa are the chief crops grown. In dry seasons small-grain yields may exceed those produced on the upland soils, owing to a higher moisture supply and more protection from hot winds, but if the spring season is rather wet the stalk growth is too rank and the crop is more susceptible to lodging. Successful stands of alfalfa are grown without liming on this soil, but the yields average higher and the crop endures for a longer period when the ground is well limed prior to seeding. Alfalfa does better on the areas with friable subsoils than on those with the heavier subsoils. The chief crops of the county are probably more dependable on this soil than on the Verdigris soils because of immunity from flooding, but average yearly yields do not vary to an appreciable extent.

Waukesha silty clay loam.—Waukesha silty clay loam differs from Waukesha silt loam in the presence of a surface layer having a silty clay loam texture and a slightly darker color. The subsoil is practically identical with that of the silt loam. A part of the area lying 1 mile west of Holliday has a black heavy clay surface soil, and owing to imperfect drainage it is left in pasture. It is estimated that about 85 per cent of the combined areas of the Waukesha soils are under cultivation, the rest being in bluegrass pasture.

Corn, wheat, oats, and alfalfa are the chief crops grown. Corn is more difficult to handle on Waukesha silty clay loam, and, should the season be backward or wet, the yield is affected more than on Waukesha silt loam. When rainfall is well distributed, crop yields vary little if any from those obtained on Waukesha silt loam. In general those areas having the more friable subsoils return better yields of corn than those with heavy moderately plastic subsoils. Wheat or oat yields, although variable, average about the same on all Waukesha soils in the county.

Verdigris silt loam.—To a depth ordinarily ranging from 9 to 15 inches Verdigris silt loam consists of grayish-brown, brown, or dark-brown loose silt loam and in places, usually near stream channels, the proportion of very fine sand is higher than elsewhere. In most places the topsoil grades into brown or grayish-brown silty clay loam, but in many places, at a depth ranging from 14 to 22 inches, the color is slightly darker brown than that of the surface layer. The subsoil, in general, is brown or grayish-brown fairly heavy silty clay loam or silty clay. Included with mapped areas of this soil are a few small

areas which have been formed from sediments derived largely from the Summit soils, and they have darker surface soils. Such areas occur along small creeks mainly east of Spring Hill and are too inextensive to justify separate mapping.

This soil is well suited to a wide diversity of crops. Corn is the most important crop, and yields are usually higher on this soil than on any of the upland soils except Marshall silt loam of the dark-colored upland soils. Alfalfa succeeds equally as well as on any of the upland soils, especially if the ground is well limed. Small grain is not so commonly grown as on the upland soils, although yields in dry seasons surpass those produced on the uplands. If the season is wet, the vegetative growth is very rank and very susceptible to lodging whenever heavy winds or rains occur.

Corn ordinarily yields from about 30 to 50 bushels an acre, wheat from 13 to 26 bushels, oats from 20 to 30 bushels, and alfalfa from 3 to 4 tons.

Verdigris silty clay loam.—Verdigris silty clay loam is very similar to Verdigris silt loam but the surface soil as well as the subsoil contains a higher proportion of clay than the silt loam. In a few places where the areas border on Verdigris very fine sandy loam, the lower part of the subsoil consists either of silt loam or very fine sandy loam.

Areas of this soil occur mainly northwest of De Soto, and they occupy comparatively lower situations than the surrounding areas of Verdigris silt loam and Verdigris very fine sandy loam; consequently surface drainage is more or less imperfect in wet seasons. In normal seasons, however, yields are about the same as those obtained on Verdigris silt loam.

DARK-BROWN, BROWN, OR REDDISH-BROWN SOILS WITH MODERATELY FRIABLE SUBSOILS

This group includes five soils belonging to the Bates, Labette, Riverton, and Newtonia series. The surface soils vary widely in thickness and in composition depending on the extent to which erosion has removed the dark upper layer. Where the land has been undisturbed for a long time the surface soil is as dark colored as the surface soils of Group 1 but in many places this layer is partly or completely removed giving the surface a spotted appearance. The thinner surface soils are tinged with red in many places. The subsoils are reddish brown or brown, and they range in texture from heavy silty loam to silty clay.

Corn, wheat, oats, grasses, and alfalfa are the chief crops grown on the soils of this group, the relative acreages being about the same as on soils of Group 1. In average years as well as in unusually wet years, yields of corn are slightly higher than those produced on the Group 3 soils but lower than on the soils of Group 1. Yields of wheat and oats differ very little from those on Group 3 soils but, as corn is the most important crop, a comparatively lower acreage is used for small grains.

Owing to the moderately friable subsoil, leaching of lime, or calcium carbonate, has progressed to greater depths than in the heavier soils of Groups 3 and 4. Therefore, in order to obtain the best stands and yields of clovers and alfalfa, liming is necessary. Inasmuch as the moderately friable subsoil does not seriously obstruct root development, orchard fruits, berries, and grapes do fairly well on these soils but not so well as on soils of Group 1.

Most of the areas, other than a few which occupy hill crests or ridge divides, have a 4 to 7 per cent slope which is sufficient to cause erosion under careless treatment. The loose fine-granular, or crumb, structure of the surface soil has been favorable to a fairly high moisture-absorbing as well as moisture-retaining capacity, but the continual cropping of these soils to grain has resulted in loss by erosion. As the surface soil becomes thinner, erosion is more active, the general tilth becomes more or less impaired, and the productive capacity of the soils is gradually lowered.

Labette silty clay loam.—Labette silty clay loam includes areas which were formerly Labette silt loam, but which have been subjected to severe erosion. In general the slopes are more pronounced than in areas mapped as Labette silt loam.

This soil occurs mainly on the upper slopes lying above the undifferentiated Summit, Labette, and Newtonia stony silty clay loams in the proximity of Cedar and Mill Creeks. Continual cropping to corn and small grain has facilitated erosional activity to such an extent that at the present time a number of fields are abandoned and utilized only for grazing purposes. Sheet erosion followed by gullying has brought about this condition. Approximately 75 per cent of this soil is under cultivation, and is therefore subject to severe erosion because of its sloping surface. The present topsoil is so thin and intermixed to such an extent with the subsurface soil and subsoil by plowing that it would require a number of years of careful management and frequent cropping with legumes to bring the soil to a good state of productiveness. At the present time only 11.1 square miles are included in this soil, but it is probable, if the present system of cropping continues, that a number of areas now mapped as Labette silt loam will in the future, because of erosion, be converted into Labette silty clay loam.

At present the surface soil consists of a 5 to 8 inch layer which varies greatly in texture and color. In cultivated fields it is brown or pale reddish brown in color and ranges in texture from heavy silt loam, through silty clay loam, to silty clay. The characteristics of this soil, therefore, are influenced by cultivation and erosional activity, and erosional activity is influenced by the degree of slope, crops grown, mode of cultivation, amount of precipitation, degree of erosional resistance of the soil, and various other factors.

The subsoil is essentially identical in character with that of Labette silt loam, but in bodies which are closely associated with Clinton silt loam the color is light reddish brown, with very little mottling of any kind. In such places the material is compact, and approaches clay in texture. A few areas of virgin silt loam are included in mapped areas of this soil, but the topographic features are so pronounced that after cultivation for a few years the texture would average silty clay loam. The surface soils of these included areas are thinner and contain a correspondingly lower amount of organic matter.

Crop yields on Labette silty clay loam are lower than on Labette silt loam. The thinning of the surface soil has lowered the organic-matter content and impaired the tilth of the soil, as well as its productive capacity in general. All the crops adapted to Labette silt loam will grow on this soil but with less success. Wheat, oats, or barley are the crops which do best because of their shallow root systems and early maturity. Yields of these crops are somewhat

lower, probably from 15 to 20 per cent, than on Labette silt loam. Corn, one of the main crops grown, has declined in yields very noticeably, in some places as much as 40 per cent. Cowpeas, soybeans, or sweetclover are good crops for building up the productiveness of the soil, especially when they are plowed under, but in view of the fact that the seed is rather expensive and the profits which accrue through the use of these crops are not always immediate, they are not extensively grown. As a number of farmers are renters many of them can not afford to grow these crops.

Bates loam.—In virgin areas the surface soil of Bates loam is medium-brown or rather dark-brown loam to an average depth of about 12 inches, but erosion on sloping land has removed part of the dark-colored layer so that lighter-colored material is plowed up giving the soil of plowed fields a brown or rather light-brown color. The subsoil, beginning at a depth ranging from 8 to 16 inches, is yellowish-brown or reddish-brown material containing considerable clay, in some places approaching fine sandy clay, and with increase in depth mottlings of red, yellow, and gray are pronounced. In most areas fragmentary shale and soft sandstone are common from 20 to 40 inches below the surface.

Bates silt loam.—The Bates soils, being derived from fine-grained sandstone and shale material (pl. 1, C), contain a higher percentage of sand than do other upland soils in the county. Bates silt loam is distinctly a hill-land soil with rather steep slopes. The more extensive areas occur in the western and southwestern parts of the county.

This soil is underlain by comparatively thin interbedded shales and sandstones, the sandstone material in most places being fine in grain and less abundant than in Bates loam. The subsoil material is friable and the characteristic variegated coloring or mottling is less pronounced than in the loam especially in the lower part of the subsoil. The slopes being more gradual, erosion is not so active as on the more hilly areas mapped as Bates loam. Therefore the surface soil, in general, is darker in color and of greater depth than that of the loam.

Riverton loam.—Riverton loam is of small extent and is not typically developed in Johnson County. It occurs only on the upper slopes of areas constituting remnants of very old high terraces. Several small areas are in the northwestern part of the county along the county line. One better-developed area in which the surface soil is brown or dark-brown silt loam from 8 to 14 inches thick, underlain by reddish-brown or dull-red friable clay containing more or less sand and gravel, is 1½ miles southwest of Holliday. The percentage of gravel increases with depth and varies in amount from place to place. The gravel beds underlying this particular area range from 20 to 40 feet in thickness, and large quantities of the gravel have been used as ballast for railroads. The areas along the northwest county line are not underlain by gravel beds. Here the surface soil consists of brown silt loam or loam about 10 or 12 inches deep, underlain by reddish-brown friable silty clay loam having, in many places, a moderately high content of sand. The subsoil is similar to that of Labette silt loam, but differs in that locally it contains deposits of clay and sandy clay intermixed with the brown cherty waterworn gravel.

Newtonia silt loam.—Newtonia silt loam consists of brownish-red silt loam to a depth ranging from 12 to 16 inches. This layer, the surface soil, is underlain by a similar-colored subsurface layer of

friable silty clay loam ranging from 3 to 6 inches in thickness. The subsoil is reddish-brown silty clay containing some dark-brown stains and almost black soft concretionary material. In places limestone rock is present at a depth ranging from 3 to 4 feet. This soil is inextensive, the main areas occurring along Spring Creek, southeast of Gardner.

DARK-BROWN SOILS WITH HEAVY SUBSOILS

This group includes Summit silt loam, heavy phase, Summit silt loam, flat phase, Summit silty clay loam, and Summit silty clay. These soils cover 11.2 per cent of the total area of the county. They occur on the more gently undulating slopes and on broad rounded divides, the flat phase occurring in rather broad flat areas between drainage divides. Surface drainage of the flat phase is not always good, especially in wet seasons.

All the land occupied by these soils is either cultivated or in pasture. It is estimated that about 12 per cent is in bluegrass pasture and possibly less than 1 per cent in virgin prairie grass. The chief crops grown are corn, wheat, oats, alfalfa, and clovers. Inasmuch as the rainfall is more or less uncertain in late summer when most needed for corn, the comparatively stiff subsoil causes this crop to suffer more than when it is grown on the soils of Group 1. If the rainfall is well distributed in late summer yields do not vary greatly from those produced on the Group 1 soils. In 1927 and 1928, years with sufficient summer rain, yields of corn averaged around 40 bushels an acre. Usually, however, average yearly yields range between 28 and 35 bushels. Small grains do well and the yields are not so variable from year to year as are corn yields. Ordinarily average wheat yields range from 15 to 20 bushels, and oats from 25 to 35 bushels. Small grains are better suited to Summit silt loam, flat phase, than is corn, and a higher acreage is devoted to oats mainly because the yields are not so adversely affected in unusually wet or dry seasons.

Erosion has not been a serious problem on this soil, but of late years parts of fields having a 5 or 6 per cent slope or more have been so thinned that, when plowed, a thin layer of heavy clay is turned up each year. Soils in this group can not withstand so great an amount of erosional wastage as those of Group 1 without serious impairment of the tilth and productive capacity.

Summit silt loam, heavy phase.—The profile of Summit silt loam, heavy phase, is essentially the same as that of typical Summit silt loam. It differs from the typical soil chiefly in the darker color and heavier texture of the surface layer which in the heavy phase is nearly as heavy as silty clay loam. The subsurface soil and upper subsoil layer are slightly darker than the corresponding layers of the silt loam, and the heavier silty clay loam subsoil usually begins at a depth of about 7 or 8 inches from the surface instead of 10 or 12 inches as in the silt loam. The olive-gray color of the lower subsoil layer is more uniform than in the typical soil, and mottling or splotching of yellow or brown shades are not so common.

Summit silt loam, flat phase.—Summit silt loam, flat phase, is essentially like Summit silt loam, except that the subsoil of the flat phase is slighty stiffer in places and both surface drainage and underdrainage are more or less imperfect.

Summit silty clay loam.—The surface soil of Summit silty clay loam is very dark grayish-brown silty clay loam. At a depth ranging from

6 to 12 inches it grades into olive-gray silty clay which at a depth of several feet is underlain by yellow or olive-yellow silty clay. This soil has about the same agricultural value as the heavy phase of Summit silt loam. The high content of organic matter and the heavy texture cause the soil to hold water after heavy spring rains and to remain so wet that crops are late in maturing. Corn is the principal crop but small grains do well. Corn yields range from 30 to 40 bushels an acre, wheat from 15 to 25 bushels, and oats from 25 to 35 bushels.

Summit silty clay.—Summit silty clay is a soil of minor importance in Johnson County as it covers a total area of only 1.3 square miles. It is locally known as "black gumbo." The surface soil is shallower than that of Summit silty clay loam, being underlain at a depth of 6 or 8 inches by heavy black clay. In both soils the black clay continues to a greater depth than in Summit silt loam, and it gradually passes into olive-gray clay. Summit silty clay is slightly less productive than Summit silty clay loam.

GRAYISH-BROWN SOILS WITH CLAYPAN SUBSOILS

Parsons silt loam is the only representative of this group of soils in Johnson County. It is characterized by a stiff clay subsoil or claypan which is nearly impervious to the downward movement of water. Only such crops as the small grains can be grown successfully in average seasons, and for that reason the agricultural value of the land is considerably decreased. In wet seasons production of all crops is lowered because of slow drainage. Typical Parsons silt loam areas have a nearly flat or undulating surface. Some flat, more nearly level areas, in which surface drainage is very poorly developed, are included in mapping.

Parsons silt loam.—Parsons silt loam is the most deceptive soil type in the county. In general appearance, it very closely resembles Summit silt loam, and when moist it also resembles Marshall silt loam. When thoroughly dry, however, the dark-brown color changes to grayish brown. The gently undulating or rather flat surface relief seems sufficient to insure good drainage, but during wet periods when the ground becomes thoroughly saturated, water drains off very slowly and cultivation or handling of any crop is delayed more than on other soils in the county under similar conditions. A corn crop may be in good condition while young, even up to the tasseling stage, but if the weather should be dry the condition would change rapidly and the yield would be lower than on other upland soils of the county. An orchard set out in this soil may do well until the trees are from 12 to 15 years old, and then begin to die out. According to a careful count of farmhouses occupied, unoccupied, and abandoned on this soil it was found that 95 houses were inhabited, 6 uninhabitable, and 10 abandoned.

The surface soil is from 6 to 11 inches deep, averaging about 8 inches, and it is abruptly underlain by extremely heavy stiff dark grayish-brown clay which extends downward to an average depth of about 3 feet and at this depth grades into lighter-textured olive-gray soil material.

The stiff clay subsoil, or claypan, together with its nearness to the surface, has a direct effect on crop yields. It retards downward percolation of local rainfall, rendering underdrainage imperfect, and it obstructs downward root development, especially of orchard or small-fruit crops, causing a large percentage of the roots to extend laterally over the stiff subsoil. As a consequence the plants suffer for moisture during dry weather. Corn roots can not collect sufficient moisture

to withstand droughty periods and produce good yields. This is partly explained by the fact that irregular cracks form in the subsoil, because of the great contractive power of the dense clay material, thereby increasing evaporation to depths of 3 or 4 feet. Should heavy rains occur in the fall a very considerable quantity of silt is washed down into the cracks. Consequently this process, or translocation of more or less of the surface soil, has resulted in thinning the covering of a number of old cultivated fields, which now have only about 4 or 6 inches of surface soil.

Lime is sufficient, beneath the stiff heavy subsoil, to favor the growth of leguminous crops, but the surface soil and subsoil are strongly acid and require liming to start legumes properly. Even where this is done the heavy subsoil obstructs alfalfa root development to such an extent that stands are short lived. Sweetclover does fairly well and is an excellent crop to grow as pasturage for livestock or in rotations. When plowed under green, a liberal amount of organic matter is incorporated in the surface soil. The vigorous and sturdy root system of sweetclover opens the stiff subsoil more than does any other crop that can be grown.

Small grains and grasses having shallow root systems are the most favored crops. A considerable acreage of English bluegrass is grown for seed and seems to do very well. Wheat, oats, and barley are grown successfully because they mature before dry, hot weather sets in. Some farmers use commercial fertilizers. Applications of superphosphate or bone meal materially increase crop yields, and their use usually proves profitable.

Corn yields ordinarily range from about 15 to 30 bushels an acre, wheat from 12 to 20 bushels, and oats from 15 to 30 bushels. The largest areas of this soil are in the western part of the county. Nearly all the land is or has been cultivated; the remainder is in virgin prairie grass.

LIGHT-COLORED SOILS WITH FRIABLE OR MODERATELY HEAVY SUBSOILS

This group of soils is far less extensive than the group of dark-colored soils. It includes Knox silt loam, Knox silty clay loam, Clinton silt loam, Elk silt loam, and Verdigris very fine sandy loam. The main areas of the Knox soils occur east and west of Shawnee in the northeastern part of the county. Clinton silt loam occurs in the northern and eastern parts along the upper slopes of the larger creeks, Elk silt loam on stream terraces in all parts of the county, and Verdigris very fine sandy loam in the bottoms bordering Kansas River. The areas of the upland soils range from rolling to hilly, the soils of the more hilly areas having been subjected to more or less rapid erosion. The surface soils are thinner, therefore, than those of soils in which erosion has not taken place. Because of the slight depth at which the heavier subsoil occurs the severely eroded areas have been identified as Knox silty clay loam. A few small areas of Clinton silty clay loam were included within the silt loam because their total area was not sufficient to justify independent recognition on the map.

It is estimated that 60 per cent of Knox silt loam, 97 per cent of Knox silty clay loam, and about 90 per cent of Clinton silt loam are under cultivation.

The chief need of all these soils is a higher supply of organic matter. This can best be attained by growing leguminous crops in the rotation and by the direct application of stable manure. Proper terracing and

contour cultivation of the slopes will retain the greater part of the surface soil and prevent disastrous gullying.

With this group are included a number of light-colored bottom soils of the Verdigris series having sandy subsoils. They vary in texture even within short distances, but the most extensive soil is the very fine sandy loam so the smaller areas of other textures have been combined on the soil map with Verdigris very fine sandy loam. All the areas of this soil occur in the Kansas River Valley, and about 98 per cent of the total area is cultivated. For the most part areas of these soils are almost flat, but narrow strips in close proximity to the banks of Kansas River and lower than the main flood plain are somewhat billowy and hummocky. Both surface and subsoil drainage of Verdigris very fine sandy loam are excellent.

Knox silt loam.—The surface soil of Knox silt loam consists of a layer of brown or grayish-brown mellow, flourlike silt loam 6 or 8 inches thick, underlain by a slightly lighter-colored silt loam layer. The subsoil, which begins at a depth of 12 or 14 inches, is friable yellowish-brown silty clay loam grading into slightly heavier silty clay loam at a depth ranging from 18 to 22 inches, maintaining this texture to a depth of 36 or 40 inches. The underlying substratum is yellowish-gray or yellow heavy silt loam which continues downward to indefinite depths.

The loose friable permeable character of the Knox soils allows a wide feeding range for plant roots. Therefore grain, truck, garden, and orchard crops do well. The productive capacity depends largely on the content of organic matter. Water percolates readily through both surface soil and subsoil, but the moderate or steep slopes on which the soil occurs prevent the maximum absorption of rainfall unless contour cultivation or terracing is practiced. The organic-matter content of this soil has always been rather low. The mapped areas in close proximity to towns are largely in bluegrass pasture and are held for speculative purposes. The chief crops are grapes, berries, and vegetables, and there are a few small orchards. Elsewhere the soil is cropped almost entirely to corn and wheat, with some alfalfa. Wheat is more commonly grown on Knox silty clay loam. The average yields are about the same as on Labette silt loam but lower than on Marshall silt loam.

Knox silty clay loam.—Knox silty clay loam is merely Knox silt loam from which part of the surface soil has been removed by erosion. The soil is therefore more or less variable but decidedly heavier in texture, lighter brown in color, and somewhat lower in productivity than the silt loam.

Clinton silt loam.—Clinton silt loam differs chiefly from Knox silt loam in that its subsoil is heavier. The upper subsoil layer, which begins at a depth of about 8 or 10 inches is yellowish-brown silty clay loam, and it is underlain at a depth of 14 or 16 inches by moderately friable reddish-yellow or pale reddish-brown silty clay. The lower subsoil layer, beginning at a depth ranging from 26 to 28 inches, grades into brownish-yellow moderately friable silty clay, and at a depth of about 38 or 40 inches the material is buff or yellowish-red moderately friable silty clay.

Clinton silt loam is cropped mainly to wheat and corn, and of late years wheat is gradually gaining in acreage because the gradual thinning of the surface soil is making corn yields less dependable than wheat yields. Wheat matures before dry weather sets in, and yields on this soil are comparable with those on other soils of the county.

Grapes, truck crops, and orchard crops do well but not so well as on the Marshall and Knox soils.

Elk silt loam.—This is a light-colored terrace or second-bottom soil. It occurs in well-drained benchlike areas along the main creeks of the county, in most places lying from 15 to 30 feet above the adjoining first bottoms, and it is not subject to overflow. It occupies comparatively flat areas with smooth surfaces and also areas having slight slopes adjacent to the hilly upland.

The surface soil of Elk silt loam consists of light-brown, yellowish-brown, or grayish-brown floury silt loam about 9 or 10 inches thick, ordinarily underlain by a layer of slightly lighter-colored silt loam or silty clay loam about 2 or 3 inches thick. The subsoil is moderately tough yellowish-brown silty clay which grades into silty clay loam at a depth ranging from 22 to 40 inches.

Corn is the most important crop grown on Elk silt loam. Corn yields average higher than those on Parsons silt loam but less than those on the dark-colored alluvial soils, such as the Waukesha soils.

Verdigris very fine sandy loam.—The topsoil of Verdigris very fine sandy loam consists of a layer of light brownish-gray very fine sandy loam in most places 10 or 12 inches thick, underlain by similar-textured soil material of slightly lighter tint due to its lower content of organic matter. At a depth ranging from 24 to 40 inches the underlying soil material closely approaches a silt loam in texture, and it is slightly darker than the surface soil, which in all probability denotes that it is old alluvium deposited prior to intensive cultivation of the Central West and before later sediments were deposited. The areas nearest Kansas River are more variable in the surface soil and especially in the lower subsoil layer because of unequal deposition of sediments at previous overflow periods.

Veridgris very fine sandy loam is suitable to a wide range of crops mainly because of its exceptionally loose friable surface soil, subsoil, and substratum and its nearness to the underlying ground water. Its light sandy texture provides an unusual amount of warmth and thereby insures an early start of commercial truck crops, especially potatoes and melons. The ease with which it can be cultivated and kept free from weeds, together with its moisture-absorptive capacity afford excellent tilth at all times, and crops make rapid growth. The loose structure of the soil material insures well-rounded and clean specimens of various root and tuber crops. Root development being unobstructed, nursery stock does well, but very few nurseries are located in the county.

Potatoes are the main commercial crop on this soil. Most farmers who own this kind of land devote a certain acreage to potatoes, corn, and alfalfa or sweetclover. After the potato crop is harvested, the land is generally sown to turnips. These are marketed as long as the price is good but left in the ground and turned under should the market price become too low. Watermelons, cantaloupes, and cucumbers are grown commercially by some farmers, and large acre yields are obtained. The largest acreage is devoted to corn, but ordinarily potatoes are the most profitable crop grown. Potato yields ordinarily range from 90 to 175 bushels an acre, corn from 30 to 50 bushels, wheat from 13 to 20 bushels, oats from 20 to 35 bushels, and alfalfa from 3 to 4 tons.

The incorporation of organic matter is the chief need of this soil. A common practice of late years is to seed part of the land to sweetclover, soybeans, or cowpeas, preferably cowpeas, and to plow them under

in the early fall as a green-manure crop. This not only increases the available nitrogen content in the soil but supplies a liberal quantity of organic matter in which the soil is very deficient. Commercial fertilizers are used rarely, but all the available barnyard manure is applied, usually to fields planted to corn.

A loam phase of Verdigris very fine sandy loam occurs in slightly lower-lying situations where drainage is more or less retarded. The surface soil, which has a comparatively higher content of silt and is somewhat darker than the typical soil, is underlain by either silty clay loam or clay loam at a depth ranging from 15 to 22 inches. Below a depth ranging from 30 to 40 inches lighter-textured material of varying thickness prevails. All this included land is cultivated.

UNDIFFERENTIATED SOILS OF ROUGH STONY AREAS

Soils of this group include the rough, steep, stony land of the county, the largest areas of which occur along the large creeks. These soils are nonarable, about 95 per cent being in virgin timber consisting mainly of oak, hickory, elm, and locust with some walnut, hackberry, redbud, wild cherry, and sycamore.

The utilization of these soils is restricted practically to grazing. The areas when cleared, if the large stones be removed, make fair pasture for livestock until late summer, when the usual dry weather greatly reduces their pasturage value. The shallowness of the soil material over the underlying limestone makes the areas more or less droughty.

In some places the underlying limestone is from 3 to 4 feet below the surface and the overlying soil material is comparatively free of limestone fragments. In such places fruits, such as grapes, berries, and peaches, do fairly well, but a very small part of the total acreage, consisting of 28,864 acres, is utilized for such crops.

Most of the limestones underlying these areas are high in carbonates and if ground would make good agricultural lime.

Summit, Labette, and Newtonia stony silty clay loams, undifferentiated.—It is estimated that about 50 per cent of these undifferentiated soils have grayish-brown or grayish-black silty clay loam or silty clay surface soils underlain at a depth ranging from 10 to 15 inches by dark-gray or grayish-black heavy clay subsurface soils. The subsoil is dark olive-gray clay which merges into lighter olive-gray clay very similar to that underlying the heavier soils of the Summit series. Fragments of limestone are strewn over the surface or have been removed and built into stone fences, and they are also present in varying amounts in the surface soil and subsoil. In many places the soil can not be penetrated with a soil auger to a depth ranging from 15 to 20 inches. In a number of places along the upper slopes, the surface soil consists of dark-brown or chocolate-brown silty clay loam, from 8 to 12 inches in thickness, underlain by reddish-brown or mottled red, brown, and gray subsoils, similar to the underlying subsoils of the Labette soils, or by dull-red subsoils similar to the subsoils of the Newtonia soils, but everywhere having more or less fragmentary limestone material at the surface and through the subsoil. In other places the surface soil is light grayish brown or yellowish gray, and the subsoils are tinted with red like the subsoils of Clinton silt loam, but they contain the usual limestone fragments. In places, spots of bluish-gray shaly material are exposed at the surface, and this shale is common at certain levels, usually underlying various limestone beds.

These variations being of no agricultural significance, and because of the inaccessibility of the areas and difficulty in making such separations all the soils are included in the above-named classification. However, the boundaries between these shallow stony soils and the deeper soils of the county have been placed on the soil map with great care.

SOILS AND THEIR INTERPRETATION

Johnson County covers an area underlain by several different soil-forming materials including limestone, sandstone, shales, loess, and remnants of glacial drift. Limestones underlie the areas lying mainly along the steeper slopes bordering the larger creeks in the northern, eastern, and southern parts of the county; sandstones are usually more or less interbedded with shales and occur mainly in the southwestern part; areas underlain mainly by shales lie in the central and western parts; those underlain by loess in the northeastern part; and small areas underlain by glacial drift in the northwestern part.

The natural vegetation on the smooth parts of the county was grass, but on the rougher areas, along the bluff belts of the larger streams there were strips of woodland. Within the area where grass was the natural vegetation the soils are dark colored. The organic matter is disseminated through both the surface soil and the mineral constituents therein. In the rolling areas where trees constituted the natural vegetation the surface soils are light in color if the total thickness of the layer is taken into consideration, a dark-colored surface layer being not more than 3 inches thick. The thickness of the dark-colored surface layer constitutes the most important difference between the dark-colored and light-colored soils.

The average annual rainfall of the region, 37.73 inches, has been sufficient to leach such carbonates as were present in the original parent material to a depth ranging from 4 to 5 feet in soils having friable subsoils, but ordinarily it has not been sufficient to leach the soils having heavy claypan layers to a depth exceeding 3½ or 4 feet. Soils derived from mixed sandstones and shales do not consistently contain calcium carbonate at a depth of less than 5 or 6 feet, and in most places this material is lacking to a depth of more than 10 feet.

Under the prevailing climatic conditions, the various soil-forming materials have given rise to several soils with very different profile characteristics, their differences being influenced largely by the surface relief and by the length of time to which the soils have been subjected to weathering. The upland soils lying generally on smooth surfaces have been most thoroughly weathered.

The dark-colored upland soils in the northeastern part of the county which, for the most part, have been weathered from parent loess have very deep silty surface soils and unusually friable subsoils. The soil most typical of this group, Marshall silt loam, may be described from the surface downward, as follows:

(1) A dark-brown very friable silt loam layer, 14 inches thick, which contains a high content of organic matter and is covered with a thin veneer of light-brown loose fluffy partly decayed organic material ordinarily about one-fourth inch thick. The main layer is almost structureless or single grained, but some soft fine rather rounded granular particles are present, ranging from about one-sixteenth to one thirty-second inch in diameter. Rather imperfectly developed laminæ occur in the upper 3 inches of the layer. The lower half of

this layer is more firm in place and possibly a trifle heavier. Numerous insect and worm casts measuring about one-sixteenth inch in diameter are present, and in places the soil material within them is slightly lighter in color. This layer has a high percentage of finely disseminated organic matter and is thickly matted with grass roots, especially through the topmost 6 or 8 inches. (2) A transitional layer about 6 inches thick in which the color changes gradually from fairly dark brown in the upper part to light brown in the lower, and the texture from heavy silt loam to silty clay loam. The structure is fine granular, the structural units being more or less rounded and from one-sixteenth to one-eighth inch in thickness. The units have a coating or film of slightly darker brown on the outside than on the inside as indicated when a small bit is either cut or crushed. (3) The layer of maximum compaction. This layer, although of maximum compaction in the Marshall soil, is less compact than the corresponding layer of any other soil in the county. It contains a slightly higher percentage of clay than the layers above, but the difference is small. Granulation is present in the upper part but gradually decreases with depth and is not recognizable in the lower part of the layer. This layer is 8 inches thick, the lower part being 30 inches below the surface. The color is light brown in the upper part and gradually changes with depth to yellowish brown. The film, or coating, on the cleavage faces of the structure particles is scarcely discernible. Large blocks break into rather well-formed prisms. Small threadlike lines or decayed root hairs of dark-brown color are more conspicuous than in the overlying layer but are very sparingly distributed. (4) A transitional layer between the third layer and the parent loess. This layer is about 12 inches thick and very indistinct. It consists of very friable heavy silt loam containing yellowish-brown and grayish-yellow splotches. It breaks into rather sharp angular particles, some of which are prismatic. The lower part of this layer effervesces slightly when treated with hydrochloric acid, indicating the presence of calcium carbonate. No lime concretions were noticeable. This material is essentially the same to a depth ranging from 6 to 50 feet or deeper as examined along cuts or banks. It has the peculiar ability to stand for a long time in perpendicular walls.

Variations in the color and thickness of the surface layer, as well as the thickness of the respective layers, occur in different places. In the more sloping areas the surface layer is thinner, and, although the remaining layers are almost identical in their characteristics, they vary somewhat in thickness and depth below the surface. Areas on the lower slopes have a more pronounced dark-brown coloring in the surface layer and a higher percentage of grayish yellow in the lower layer, the grayish-yellow soil in many places predominating over the light-brown or buff-colored material. The presence of lime is noticeable at a depth ranging from 3½ to 6 feet. Lime concretions are present in some places.

The profile of Marshall silt loam in its fundamental features is somewhat similar to that of Labette silt loam.

A typical profile of Summit silt loam shows the following layers:

(1) A dark-gray or dark brownish-gray loose silty layer 12 inches thick. The evenly dark-colored material indicates a uniform distribution of organic matter. The upper 3 inches is noticeably laminated, the laminæ in most places being rather irregular in outline but more or less disk shaped or platelike. The laminæ extend laterally but are

not continuous. Some of them are less than 1 inch in length and others from 2 to 4 or more inches, and in most places the layers are from one-sixteenth to one-eighth inch apart from the surface downward. The laminæ are less distinct and almost unrecognizable at a depth of 3 or 4 inches. The structure of the material in this layer is very finely granular. (2) A slightly lighter-colored transitional layer 4 inches thick, the lower part of which becomes increasingly heavy and is of silty clay loam texture. The structure is very fine granular, most of the granules ranging from about one-sixteenth to one thirty-second inch in thickness. (3) A 10-inch layer of heavy plastic clay which is dark brown when wet, and when dry is grayish brown, hard, and dense, and contains some very dark-brown and yellowish-brown specks the size of small bird shot. When moist the soil material breaks down with slight pressure into an apparently granular structure. The integral parts become very hard on drying. Most of them range from one-fourth to one-eighth inch in diameter, are very angular, and are irregular in shape and size. The outside film of the particles, when wet, is apparently of the same color as the inside but on drying it appears darker. This layer may be said to be the layer of maximum compaction, but it is only very slightly heavier than the underlying one. (4) An 8-inch layer of olive-gray plastic clay, similar in texture and structure to the layer above and containing numerous rust-brown and yellowish-brown specks, also a few dark-brown round semihard pellets about three-fiftieths inch in diameter. The outside film of the structure units varies in thickness from about one one-hundredth to one five-hundredth inch, and it is decidedly darker than the insides of the particles, as indicated when the material is crushed or cut. The lower part of the layer is transitional. (5) A slightly lighter olive-gray clay layer, containing specks and pellets, as in layers 3 and 4, and a very noticeable mottling of rust-brown and yellow, together with some soft brown concretionary material. The small yellow spots are very friable, soft, and composed chiefly of silt and very fine sand. The olive-gray soil material is silty clay in texture and breaks into rather fragmental aggregates very irregular in shape and size. A few small dark-brown threadlike lines or decayed root hairs are present.

Summit silt loam, heavy phase, is essentially like the typical soil in general profile characteristics. However, the surface layer is slightly heavier and very slightly darker. The darker color is noticeable only when the soil is perfectly dry. Ordinarily the second and third layers are slightly darker, but the other profile characteristics are almost identical with the profile described.

According to the strict description of Labette silt loam, the soil as mapped in Johnson County is really a clay loam and therefore considerably heavier than the soil usually mapped as a silt loam. In the field it gives the impression of a silt loam and on the basis of its field features it is mapped as such. The particles which, in the field, feel like silt particles, on account of the granulation, are composed of a number of clay particles united in one particle. By the recently introduced methods of making mechanical analyses these particles are broken up into their component clay particles, and Table 5 (p. 16) shows the proportion of clay, silt, and sand of a clay loam. The same soil in adjoining counties, when they are surveyed, may be designated clay loam.

In the western part of the county a very different soil, Parsons silt loam, has developed, which has an unusually thin surface soil and an

unusually heavy claypan subsoil. Like the Marshall and Summit soils it is a dark upland soil occurring only on broad ridges and gently undulating slopes. A profile of typical Parsons silt loam shows the following layers:

(1) A shallow silty surface layer 8 inches thick which when dry is grayish brown or dark grayish brown and when wet is grayish black or black. The upper 3 or 4 inches of material are very slightly laminated. The laminæ, which are platelike or disk shaped and overlap one another, are rather poorly defined. A few soft rather rounded granules are present, but evidence of granulation is not distinct. (2) A very dense claypan layer 14 inches thick. The material in this layer is heavy, tough, and waxy when moist and extremely hard and intractable when dry. It is very dark brown or black when wet and grayish brown when dry. When broken in a moist condition the soil separates into aggregates which are somewhat cubical in shape and have a coarse blocky structure, but when the soil is dry and allowed to slacken by wetting and drying, the structure is medium or coarse fragmental. The aggregates or units range from one-eighth to one-half inch in thickness and are very sharply angular and very irregular in shape and size. The surfaces of the structure units have a coating or film of dark grayish-brown material ranging in thickness from one five-hundredth to one thirty-second inch, the thicker coatings being usually more or less vertical in position and the thinner ones oblique or otherwise very irregular in outline. The insides of the units are noticeably lighter brown than the outsides. A few small rust-brown specks are present, but streaked and mottled material is absent. This layer is 6 inches thick and consists of very dense heavy-brown clay, the color merging into lighter-brown shades and the clay into soil material of considerable less density. (4) Moderately friable olive-gray silty clay loam or silty clay having a granular-fragmental structure. This layer extends from a depth of 32 to a depth of 50 or more inches. It is marked with a few dark-brown specks and an occasional brown streak and has a distinct splotching of yellowish brown. With increase in depth rust-brown markings and yellowish-brown splotches in the olive-gray soil material is more pronounced. In the upper part of this layer the coatings, or films, are thin, but they are slightly darker than the interior of the structure units as shown when the particles are cut or crushed. In the lower part of the layer the particles are covered by a thin film, but it shows no marked difference in color from the soil mass. At points ranging from 1 to several feet apart, darker streaks are common and extend downward a foot or more into the upper part of this layer.

Tests show that layers 1 and 2 are strongly acid; 3, neutral; and 4, neutral or alkaline. The soil material of the lower layer effervesces freely when treated with hydrochloric acid indicating the presence of calcium carbonate. However, no concretions were observed in the profiles described, but in places, along road cuts, lime concretions are present, which vary greatly in distribution and quantity.

Under different conditions the profile described varies greatly. In virgin areas the grass roots which bind the topsoil allow only a minimum quantity of surface silt to penetrate the underlying layers during excessively wet periods immediately following droughty periods. In cultivated fields, especially cornfields, during periods of drought, many large cracks, from one-half inch to 1½ inches in width, form, because no binder is present to hold the thin surface soil together.

This greatly increases evaporation, and in many places the cracks penetrate to the parent material. Heavy rains following periods of drought cause a certain amount of the surface soil to wash down into the cracks before the walls of the dense clay have time to close. This process is more rapid than the usual translocation of the finer soil particles by the process of infiltration or eluviation. The surface soil in some fields is only from 4 to 6 inches thick, whereas virgin strips along fences average 8 inches. Inasmuch as the relief is very gently undulating, or almost flat in places, no great amount of soil is washed away by sheet erosion, and after close examination of soil profiles in plowed fields, it is very apparent that the heavy textures in such fields are the result of the process described.

Profiles of the Parsons soils occurring along narrow ridges in the northern and north-central parts of the county and closely associated with Labette silt loam have a more decided marking of brown and yellowish brown in the lower part and a lighter-brown or solid-brown claypan layer. Areas of this character, however, are very inextensive. The lower layer, especially in places in the northwestern part of the county, consists of very friable heavy silt loam or silty clay loam, whereas this layer in close proximity to mapped areas of Summit silt loam, is considerably heavier, ordinarily silty clay in texture, and the surface soil is about 10 inches deep.

In the western and southwestern parts of the county are some higher ridges, the soils on which owe their origin to fine-grained sandstone and shaly material. Although these soils are dark, their development has not attained such a high state of maturity as the soils already described, but they may be regarded as normal soils. A description of a typical profile of this soil, Bates loam, is as follows:

(1) A 12-inch surface layer of medium-brown mellow loam containing a considerable amount of fine sand and numerous insect and worm intrusions. Lamination is very indistinct and no definite structure is observable. (2) An 8-inch layer of brown or light-brown loam containing a slightly higher content of sandy material and having no definite structure. When crushed the soil material is slightly lighter in color. (3) A 7-inch layer of light-brown or rather light rust-brown material with a slightly red tint. The content of clay is almost enough to make the material fine sandy clay in texture. However, little compaction is noticeable. A few yellowish specks are present, and still fewer dark-brown or maroon-colored specks are discernible. The material breaks into a very soft granular structure. (4) An 11-inch layer of reddish-brown or reddish-yellow friable fine sandy clay intermixed with some shaly material in the lower part and more or less ferruginous fine-grained sandstone material. The exteriors of the structure particles are coated with grayish brown, and the interiors are either gray, yellow, brownish yellow, reddish yellow, or red. When crushed the red and reddish-yellow materials contain the least clay, and they are very friable. (5) A 12-inch layer of loose indurated shale and fine-grained sandstone mixed and variegated with splotches of yellow, rust brown, and reddish yellow. The lower part of the layer is less compact than the upper part. The last three layers are, for the most part, granular in structure. The granules are covered with a brown or grayish-brown film, and their interiors are of lighter shades of gray, brown, yellow, and red.

The imperfectly developed soils of the county differ from the soils previously described in that the different layers of the profile have

not attained normal development. Development of distinct layers has been retarded by counteracting factors such as insufficient time, resistance to weathering of the parent material, poor drainage, excessive erosion, or steep relief. Soils in which one or more of the characteristics common to the normal soils are either imperfectly developed, excessively developed, or absent are regarded as imperfectly developed soils.

In view of the fact that a comparatively small proportion of the county is made up of imperfectly developed soils and that their profile characteristics are extremely variable, no detailed profile description is given. The Summit, Labette, and Newtonia stony silty clay loams, undifferentiated, constitute a group of the most extensive imperfectly developed soils in the county. The land is so steep and stony that its agricultural possibilities are very limited. It occurs on the steeper timbered slopes bordering the main alluvial valleys, creeks, rivers, and drainage ways, which accounts for the variation in profile characteristics. The other imperfectly developed soils include the Verdigris soils of the first bottoms, the Elk and Waukesha soils of the second bottoms or terraces, and the Parsons soils of the uplands. These soils also vary greatly in their respective profile characteristics and may be regarded as the youngest or least mature soils of the county.

The light-colored upland soils are included in the Knox and Clinton series, and their total extent is comparatively small.

SUMMARY

Johnson County lies in the eastern part of Kansas, adjoining the Missouri State line. The county occupies part of a dissected plain, a remnant of which extends as a watershed ridge about a third of the distance across the county from east to west. Kansas River forms part of the northern boundary. The northern part of the county is the most thoroughly dissected.

The climate is characterized by rather hot summers and comparatively mild winters. The average annual precipitation is 37.73 inches.

Most of the soils are dark colored, having developed under the influence of a grass cover. Only those on the rougher areas have developed under a timber cover and are light in color.

The most important soils are the dark-colored ones. They include Marshall silt loam, developed from loess; the Labette soils, consisting mainly of silt loam but containing some heavier soils developed from material accumulated through the decay of limestone and calcareous shales in place; and Summit silt loam and associated heavier soils, developed from material accumulated in place through the decay of shales together with some thin beds of limestones.

Soils of less importance but covering considerable areas are Parsons silt loam, a dark-colored soil with a heavy tough clay subsoil and Knox silt loam, a light-colored soil developed from loess.

A number of other soils of comparatively little importance, so far as extent is concerned, were identified and mapped.

Johnson County is in a region in which grain and forage crops, mainly alfalfa, are the principal crops. The livestock industry, including dairying, is important. In the northeastern part of the county truck gardening and fruit growing are important industries.

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[PUBLIC RESOLUTION—No. 9]

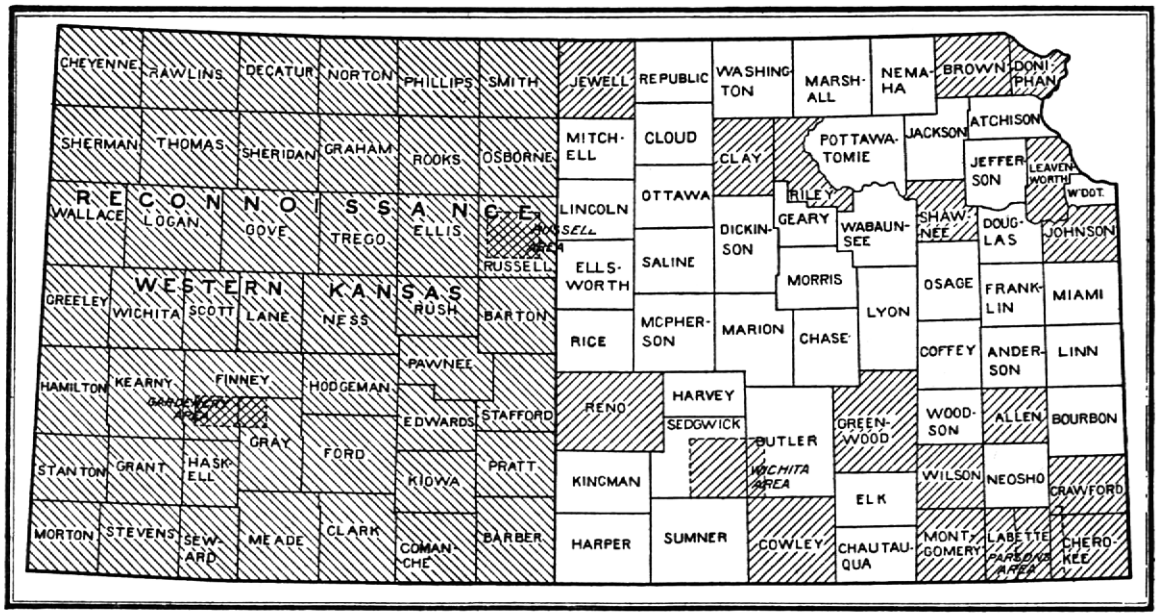
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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

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

Approved, March 4, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in Kansas, shown by shading

U. S. GOVERNMENT PRINTING OFFICE: 1932

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