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Soil Survey

of

Doniphan 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 DONIPHAN COUNTY, KANSAS

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

COUNTY SURVEYED

Doniphan County is in the extreme northeastern part of Kansas. (Fig. 1.) Missouri River, which separates this county from Missouri, forms the eastern and most of the northern boundaries. Troy, the county seat, near the center of the county, is about 13 miles west of St. Joseph, Mo. The county includes an area of 383 square miles, or 245,120 acres.

The soils of Doniphan County are underlain by a thick layer of silty material known as loess, and this in turn by shale, limestone, and sandstone beds lying almost horizontally. Through erosion, each of these rocks has been exposed in some part of the county.

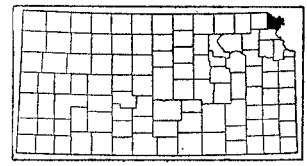

FIGURE 1.—Sketch map showing location of Doniphan County, Kans.

Physiographically, the county may be said to include two main divisions, the uplands and the alluvial lands.

The uplands, which constitute about 80 per cent of the total area of the county, range from very steep to gently undulating, but dissection everywhere is thorough enough to provide ample surface drainage. A strip of upland about 2 miles wide, lying along the Missouri River Valley, is thoroughly dissected and hilly. At the present time most of it is covered with brush or timber, and in the virgin condition practically all of it was so covered. This strip lies at a maximum elevation of about 300 feet above Missouri River. A second belt, which lies farther from the river, is about 40 miles long and ranges from about 3 to 6 miles in width and parallels this strip. Here the land is very rolling and might be classed as moderately hilly land. The rougher parts are still covered with timber. The valleys and ravines are narrow, and, as erosion is active, they are still extending headward into the upland. The land beyond the second belt, in the central and western parts of the county, ranges from smooth to rolling. Valleys are not so numerous as in the other belts, and they have a comparatively low gradient. The ridges are smooth, broad, and well rounded, and the intervening land is gently undulating or mildly rolling in contrast to the narrow divides and the highly dissected land within the belts which are drained directly into Missouri River.

The Missouri River flood plain is prevailingly flat, and all the land is subject to overflow, although complete inundation rarely occurs. Areas within the inner bends of the river and farthest

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from the Doniphan County bluff line are undulating or hummocky and contain numerous old sloughs and temporary channels.

Wolf River is the main local drainage outlet for the county. It enters from the west and flows into Missouri River on the north side of the county about 3 miles southeast of Iowa Point. This river is meandering, very shallow, and has a low gradient. Prior to the construction, in 1912, of a drainage canal along Wolf River Valley in Doniphan County, the valley floor was subject to overflow, but no overflow has occurred since the completion of the canal. Cedar, Mission, Smith, Peters, Walnut, Brush, and Independence Creeks, which drain the highly dissected upland belt adjoining the Missouri River Valley, enter Missouri River from various directions. Every farm in the county has several drainage ways which lead into the various creeks, providing excellent surface drainage. The drainage ways which enter the tributaries of Wolf River have a low gradient, and the land is less susceptible to erosion than that which is drained by the creeks flowing directly into Missouri River. The stream valleys are bordered in many places by terraces, or second-bottom belts, lying from 10 to 25 feet above the valley floors, but no terraces border the Missouri River Valley. A few alluvial-fan deposits have formed in the Missouri River Valley, the more prominent of which are east of Wathena and north of Peters Creek. These fans are 10 or 15 feet high at the base of the adjoining upland and gradually slope to the level of the valley floor a short distance from the bluffs.

Lookout Mountain lies at an elevation of 1,050 feet above sea level. Elevations at Troy and Highland are 1,093 and 856 feet, respectively. These last figures indicate railroad levels, which range from 40 to 80 or more feet below some of the higher hills in these vicinities. Elevations at White Cloud, Wathena, and Doniphan are 837, 818, and 866 feet, respectively.

In their virgin condition, the smooth areas of the county were covered with grass and the rougher parts with trees or brush. The trees are mainly oak, hickory, elm, redbud, mulberry, locust, wild cherry, ash, sycamore, cottonwood, wild plum, papaw, walnut, and boxelder, all of which are utilized chiefly for firewood and fence posts.

Well water of excellent quality is readily obtained between depths of 25 and 60 feet on the uplands and at a depth ranging from 15 to 30 feet on the alluvial lands. In places the water underlying the alluvial soils has a decided iron taste. Springs are common along the various creeks and steeper slopes where strata of limestone occur.

The population of Doniphan County, according to returns from the 1930 United States census,[1] is 14,063, all of which is classed as rural, there being no cities of 2,500 or more inhabitants. This gives an average of 36.7 persons to the square mile. Since approximately 4,600 people live in towns and villages, the number actually living on farms is about 9,500, or about 25 persons to the square mile. The people engaged in agricultural pursuits are more numerous in the central and eastern parts of the county, where truck growing is more extensively practiced than elsewhere. Troy, the county seat, has 1,042 inhabitants. Other locally important towns are Highland, Elwood, Wathena, White Cloud, Severance, Denton, and Doniphan.

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

Doniphan County was organized in 1855 and named for Alexander W. Doniphan. The earliest settlement was effected in 1837 under the auspices of the American Board of Foreign Missions. The first mission school was built in 1845, and the first school for white children was established near Highland in 1858.

Lines of the Chicago, Rock Island & Pacific, the Chicago, Burlington & Quincy, and the St. Joseph & Grand Island Railroad systems afford good transportation facilities to St. Joseph and Kansas City, Mo., and Omaha, Nebr., the chief marketing centers.

The public highways are kept in fairly good condition, but some of the roads in the hilly parts of the county are difficult to maintain. An excellent concrete highway connects Troy with St. Joseph, Mo. The roads follow section lines where surface features allow, but in the hilly regions they follow narrow watershed ridges and valley courses along streams.

Public schools are ample. Many country children go by bus to consolidated schools in towns. Rural mail delivery extends to all parts of the county, and telephones, radios, and automobiles are in common use.

CLIMATE

The climate of Doniphan County is temperate and is characterized by moderate summers and winters. Serious injury to crops or livestock from extremes of climate is rare. The winters, though comparatively mild, are more or less changeable because the wind changes frequently from north to south or vice versa. Sometimes cold snaps last for several days and the ground freezes to a depth of 12 or 14 inches, but ordinarily the ground freezes to a depth of only a few inches. Snow occasionally accumulates to a depth of 8 or 10 inches, but it remains only for a short time. The spring season is usually mild and cool but the summers are fairly hot, the heat varying considerably on account of the unequal distribution of rainfall in late summer.

In the absence of local climatic data, figures from the records of the Weather Bureau station at St. Joseph, Buchanan County, Mo., are given as fairly representative of climatic conditions in Doniphan County.

The mean annual precipitation at St. Joseph, according to records covering a period of more than 44 years, is 33.01 inches. Its distribution is rather favorable, the heaviest rainfall occurring from May to September. Some injury to crops results from excessive rains in the spring.

The average date of the first killing frost is October 15 and of the last is April 9, giving an average frost-free season of 189 days, a sufficient time to mature all the field crops common to the region. However, frost has occurred as early as September 26 and as late as April 28. Injury from early fall frost is seldom experienced unless late fall rains delay for too long a time the picking of the apple crop, but late spring frosts render the peach and plum crops rather uncertain.

Ordinarily four cuttings of alfalfa and two cuttings of red clover are made, and the growing and harvesting season are amply long to produce a crop of cowpeas or soybeans following a crop of wheat or early potatoes.

Table 1 gives the normal monthly, seasonal, and annual temperature and precipitation at St. Joseph, Mo.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at St. Joseph, Buchanan County, Mo.*

[Elevation, 967 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1915)	Snow, average depth
	° F.	° F.	° F.	*Inches*	*Inches*	*Inches*	*Inches*
December	30.2	68	−13	1.12	1.12	1.86	3.4
January	27.0	63	−24	.80	1.67	2.07	3.4
February	30.6	74	−16	1.47	.50	2.63	5.5
Winter	29.3	74	−24	3.39	3.29	6.56	12.3
March	42.4	89	−4	2.42	(1)	1.36	3.1
April	54.1	93	16	2.93	1.82	2.05	1.4
May	63.7	96	35	4.56	6.60	8.28	.0
Spring	53.4	96	−4	9.91	8.42	11.69	4.5
June	74.3	104	46	4.62	2.48	5.77	.0
July	78.8	106	53	3.04	.33	12.92	.0
August	76.9	109	46	3.26	2.00	3.12	.0
Summer	76.7	109	46	10.92	4.81	21.81	.0
September	68.8	104	32	4.91	6.09	4.30	.0
October	56.3	90	20	2.42	.42	.33	(1)
November	43.9	82	5	1.46	.20	.82	.6
Fall	56.3	104	5	8.79	6.71	5.45	.6
Year	53.9	109	−24	33.01	23.23	45.51	17.4

[1] Trace.

AGRICULTURE, ITS HISTORY AND PRESENT STATUS

Agriculture in Doniphan County has undergone a number of important changes since its early development. Originally the greater part of the county was covered with a luxuriant growth of prairie grasses. Marginal areas of forest occurred along the streams and there was an abundant tree growth on the rougher hilly land bordering the Missouri River Valley. The early pioneers settled along the streams and bluffs, where wood for fuel and building material was plentiful and where hunting, fishing, and trading were advantageous.

Among the early crops grown corn was the most important, and some oats were produced, mainly as feed for livestock. Wheat was a crop of minor importance prior to the introduction of hard winter wheat in the early seventies. Owing to the immediate success of the winter variety it supplanted spring wheat, and the wheat crop rapidly increased in importance. In the sixties and seventies some flax, hemp, tobacco, broomcorn, castor beans, and millet were grown, but these crops never attained great importance and by 1900 were seldom seen. No clover, timothy, alfalfa, or bluegrass was grown in the early days. Fruit growing, especially of apples, was begun early and has always

remained an important phase of agriculture. Peaches were formerly grown on a considerable scale, as the census figures indicate, but the danger of winterkilling and of late spring frosts has caused an almost complete abandonment of this crop. The production of grapes was rather extensively practiced in the proximity of Doniphan and elsewhere in the early days, and at the present time this crop is gradually increasing in acreage.

The average acreage of corn grown during 1925, 1926, and 1927 shows an increase of almost one-fifth over the acreage grown 50 years ago, and the wheat and oat acreages have almost doubled. The acreage devoted to red clover and alfalfa has increased greatly during the last 40 years, and several other crops, such as soybeans, cowpeas, Sudan grass, kafir, and feterita have made their appearance.

The agriculture of Doniphan County is diversified, consisting mainly of livestock raising and grain farming. Nearly all grain except wheat is utilized as livestock feed. In the eastern part of the county the production of orchard fruits, grapes, berries, melons, and numerous truck and garden crops is the more common agricultural industry. Wheat is produced most extensively in the southern and southwestern parts, and corn is grown in all parts. Dairying is receiving considerable attention, but the raising and feeding of cattle and hogs are engaged in far more extensively.

Table 2, compiled from the United States census reports, shows the acreage and production of the principal crops by decades from 1889 to 1919, and in 1924; and Table 3, compiled from the twenty-fifth biennial report of the Kansas State Board of Agriculture, shows the acreage, production, and value of field crops produced in 1925 and 1926.

TABLE 2.—*Acreage and production of principal crops in Doniphan County, Kans., in stated years*

	1889		1899		1909		1919		1924	
	Acres	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*
Corn	65,735	2,855,536	85,320	3,144,550	73,148	2,646,049	64,970	2,046,412	60,970	1,784,426
Wheat	29,597	586,618	19,127	185,540	24,063	479,219	41,687	725,699	20,718	429,313
Oats	11,612	343,465	14,590	326,440	10,766	263,233	9,407	193,585	9,183	272,771
Barley	762	18,312	559	14,510	476	7,049	78	1,312	139	3,015
Potatoes	2,164	235,341	2,023	209,892	1,365	118,730	928	43,390	663	56,859
		Tons		*Tons*		*Tons*		*Tons*		*Tons*
All hay	12,735	19,434							25,047	30,415
Tame hay			16,415	26,652	20,868	34,573	18,905	36,523		
Timothy					3,546	5,096	1,505	1,833	[1] 1,661	
Clover			9,596	13,555	5,770	6,660	2,328	3,009	[1] 10,406	
Alfalfa			76	246	3,997	12,989	12,983	29,231	[1] 10,304	
Wild hay			1,547	2,344	803	1,089	289	350	[1] 610	
Coarse fodder			503	1,169	61	112	2,541	3,281		
	Trees	*Bushels*	*Trees*	*Bushels*	*Trees*	*Bushels*	*Trees*	*Bushels*	*Trees*	*Bushels*
Apples	143,177	99,124	405,466	59,252	237,851	61,614	105,835	297,996	259,746	347,706
Peaches	20,102	3,689	52,357	111	53,298	343	7,242	34	7,501	
	Acres	*Quarts*	*Acres*	*Quarts*	*Acres*	*Quarts*	*Acres*	*Quarts*	*Acres*	*Quarts*
Blackberries			258	219,340	496	882,747	195	204,557		
Strawberries			150	244,980	315	781,140	94	148,421	299	
	Vines	*Pounds*	*Vines*	*Pounds*	*Vines*	*Pounds*	*Vines*	*Pounds*	*Vines*	*Pounds*
Grapes			326,775	832,933	203,701	249,561	147,525	881,073	307,128	

[1] Included in hay.

TABLE 3.—*Acreage, production, and value of principal field crops in Doniphan County, Kans., in 1925 and 1926*

Crop	1925			1926		
	Acres	Bushels	Value	Acres	Bushels	Value
Corn	74,638	2,463,054	$1,773,399	69,757	2,092,710	$1,381,188
Wheat	24,978	474,582	688,144	23,771	451,649	560,045
Oats	14,187	510,732	199,185	15,046	406,242	162,497
Barley	55	770	500	25	504	302
Potatoes	912	68,400	116,280	775	58,125	81,375
Sweetpotatoes	10	1,440	2,160	24	2,760	2,567
		Tons			*Tons*	
Alfalfa	12,170	38,744	529,638	10,306	27,826	451,129
Timothy	1,640	2,296	25,830	1,308	1,570	21,195
Red clover	10,596	16,594	159,367	11,140	15,596	233,940
Sweetclover	3,355	6,039	44,085	6,135	12,884	128,840
Timothy and clover	1,701	2,381	27,987	2,015	2,620	37,990
All tame hay	29,584	66,376	784,995	31,071	60,663	874,764
Prairie hay	313	376	3,008	229	344	3,784
Forage crops	351	3,720	8,307	80	1,273	2,020

As a source of income the livestock industry has always held an important place in the agriculture of the county, and the leading branch of this industry is the production of hogs and cattle for market. Several herds of purebred hogs and cattle are kept, but the raising of purebred livestock is not so important as the raising and fattening of hogs and cattle for market. The 1920 Federal census reported 38,015 hogs, with a value of $819,126, but owing to the depression following the World War this number had decreased almost half by 1926, as indicated in Table 4. The most important breeds of swine are Duroc-Jersey, Poland China, and Chester White. Beef cattle numbered 11,444 in 1920 and were valued at $698,537. In 1926 there was a considerable increase in the number of cattle due to the favorable adjustment of the cattle industry following the depression of 1920. The principal breeds of cattle are Shorthorn, Hereford, and Polled Shorthorn. Occasionally feeder cattle are shipped in to be fattened on the local corn crop. In view of the fact that red clover, alfalfa, and bluegrass do exceptionally well on most soils in the county, an abundance of summer pasture is provided, with plenty of good hay and forage available for feeding with the corn.

Dairying is receiving considerable attention. There were 5,201 dairy cattle in the county in 1928. On March 1, 1926, there were 477 cream separators and 54 silos in the county. The production of butter for the year ended March 1, 1926, was 101,822 pounds, valued at $37,674; the value of the milk sold for butter and cheese making was $105,429, and of milk sold for other purposes was $13,340.

There were 6,235 horses and 3,588 mules in the county in 1920; in 1925 and 1926 the numbers were considerably less, with mules becoming relatively more numerous. Most of the horses are of grade stock, the Percheron breed predominating. In general, each livestock and grain farmer raises a few colts every year and thus keeps up his supply of work horses and mules, and occasionally a few work animals are sold.

The Federal census reported 7,061 sheep and 36 goats in the county in 1920. The hilly stony land in the southern part of the county and the rough land adjoining the Missouri River Valley are commonly

used for grazing sheep. A few western ewes are bought on the market and sold in late fall or when conditions and prices are attractive. A total of 4,590 pounds of wool, having a value of $1,377, was clipped in 1926.

Almost every farmer keeps some poultry. According to the 1920 census the value of poultry and eggs in 1919 was $364,301; in 1926 the value totaled only $163,727. The amount and value of poultry and poultry products fluctuate more or less from year to year.

Table 4 shows the number aud value of livestock in the county in 1925 and 1926. The figures are taken from the twenty-fifth biennial report of the Kansas State Board of Agriculture.

TABLE 4.—*Number and value of livestock in Doniphan County, Kans., in 1925 and 1926*

Livestock	1925		1926	
	Number	Value	Number	Value
Horses	5,080	$289,560	4,543	$243,051
Mules and asses	3,221	267,343	3,356	252,539
Milk cows	4,649	264,993	4,893	288,687
Other cattle	11,924	417,340	13,029	472,301
Sheep	4,455	40,095	6,342	57,712
Swine	26,851	456,467	21,092	419,730

Of the grain crops grown, corn has been consistently the most outstanding crop. Although a few other counties occasionally produce more corn, no other county in the State produces so large an average acre yield. The average annual acre yield for Doniphan County ranges from 30 to 36 bushels to the acre, although the better land ordinarily yields from 45 to 75 bushels, and yields as high as 100 or more bushels have been obtained. More than 90 per cent of the corn is listed and on a few farms it is double listed. A small amount is checkrowed. Some of the corn crop is cut and shocked and fed as forage later on, some is utilized as silage, but the greater part is husked in the field. After the corn is husked cattle are generally turned into the fields. On some farms the corn is hogged down, and a few farmers turn feeder sheep into the field after the crop has reached maturity. The varieties of corn chiefly grown are Reid Yellow Dent (mainly), Kansas Sunflower, Boone County White, St. Charles, Johnson County White, Iowa Silvermine, and Pride of Saline.

Wheat ranks second in importance among the grain crops. Winter wheat is grown invariably, the most common varieties being Harvest Queen, Harvest King, Fultz, and Poole. Ordinarily yields range from 15 to 28 bushels to the acre, although maximum yields sometimes exceed 40 bushels. Wheat is harvested exclusively with a binder. Most of the farmers sell their crop immediately after threshing.

Oats are grown primarily as feed for work animals and as a nurse crop for clover, timothy, and alfalfa. The acreage devoted to this crop varies greatly from year to year. The average acre yield for the 13-year period prior to 1927 was 29.9 bushels. Kherson, Red Rustproof, and Kanota are the most extensively grown varieties, with Kanota predominating.

Ordinarily red clover is sown in the wheat field in early spring at the rate of 6 or 8 pounds of seed to the acre, and it usually produces one small cutting or some pasture after the wheat is harvested. The second year the first crop is customarily cut for hay and the second crop for seed. Of late years a number of farmers have realized considerable profit from growing red clover for seed, and this has stimulated its production somewhat.

Formerly timothy was seeded either alone or with red clover, but of late years this crop has declined in production and is now rather unimportant.

Sweetclover has been gaining in popularity during recent years. In view of the fact that erosion is reducing the productivity of many fields, sweetclover, because it is effective in reducing erosion, is becoming popular as a pasture and cover crop and is also a source of nitrogen and organic matter when used as a green-manure crop. No doubt this crop will occupy an important place in future agricultural practices.

Alfalfa has been a desirable hay crop for some time. The alluvial soils along Missouri River formerly produced large quantities of alfalfa hay, but in recent years production has fallen off. Ordinarily three or four cuttings of alfalfa are obtained each season. Good stands are commonly left for several years, or as long as they remain profitable.

A few minor crops, such as millet, cowpeas, soybeans, sorgo, milo, kafir, and feterita, are grown for either seed, hay, or roughage for livestock or for soil-improvement purposes. The total acreage of these crops is small.

Commercial orcharding, especially apple growing, is an important industry in the county. The land between the rows ordinarily is listed to corn for the first 1 to 3 years after planting and is later seeded to red clover, especially where the land is somewhat sloping.

When young orchards are set out on rolling or steep slopes, especially after such slopes have long been under cultivation, it is important to use cover crops, preferably cowpeas, vetch, red clover, or sweetclover, to help hold the surface soil and to increase the nitrogen and organic content of the soil. When new steep land is set out to orchards it should be permanently seeded down to prevent the disastrous effects of erosion. After the trees are in full bearing, sod culture is commonly practiced, the grass being cut from one to three times each season and allowed to lie.

The apple crop is picked and delivered on the track by the growers, is sold to buyers at picking time, or is sold outright before picking. Culls or No. 3 apples are sold locally and made into cider and vinegar. Comparatively few growers grade their apples according to the United States standard grades, although a Government inspector often visits the county to supervise such grading. Careful grading and packing by the growers themselves would generally prove profitable.

The varieties of apples, in order of their importance, are Jonathan, Ben Davis, Winesap, Arkansas (Mammoth Black Twig), York Imperial, Rome Beauty, Delicious, King David, Grimes Golden, and Wealthy.

In 1927, according to the biennial report of the Kansas State Horticultural Society, there were in the county 116,553 apple, 7,655 pear, 7,101 peach, 2,448 plum, 4,527 cherry, 39 quince, and 359 apricot trees

of bearing age, and 166,308 apple, 3,516 pear, 6,388 peach, 817 plum, 1,032 cherry, 11 quince, and 149 apricot trees of nonbearing age. In 1926 the production of apples was 309,241 bushels; of pears, 9,499 bushels; of peaches, 2,296 bushels; of plums, 182 bushels; and of cherries, 401 bushels. The value of all fruit in 1926 is given as $492,077 for Doniphan County, which is more than that for any other county in the State. The minor orchard crops, especially peaches, are somtimes partly winterkilled or are damaged by late spring frosts and for this reason are less extensively grown.

Strawberries, raspberries, and blackberries are grown on a commercial scale, more commonly in the bluff section near Wathena and other points along the railroad. Frequently very large profits are realized on a few acres when the crop is efficiently and properly handled, especially if the season is favorable and the price is good. Strawberries ordinarily are grown on the higher slopes and blackberries and raspberries on lower slopes where plenty of moisture is available. In 1927, 252 acres were devoted to strawberries, 239 acres to raspberries, and 235 acres to blackberries. The yields in 1926 were 6,855 crates of strawberries, 5,490 of raspberries, and 15,049 of blackberries, according to the 1926 biennial report of the Kansas State Horticultural Society.

Grape culture is practiced to a considerable extent. Most of the vineyards are along the bluffs, especially in the vicinity of Wathena. It is important that grapes be set out in rows around the slopes and that contour cultivation be practiced in order to hold all the rainfall possible and to prevent the surface soil from washing. Early in the season when the market is good, the grapes are shipped to various northern points, and later in the season they are sold at the home markets for canning and grape-juice purposes. In 1927 there were 865 acres in grapes, which yielded 1,115,709 pounds of fruit.

In general the farms are well improved and well equipped. The average farmstead has a large attractive home, a bluegrass lawn, plenty of shade trees, and well-constructed fences about the buildings and around the fields. Substantial barns, hog houses, and chicken houses are common.

Ordinarily the supply of farm labor is plentiful and fairly efficient. The laborers are mainly white Americans; a few are colored.

In the western part of the county the size of farms is considerably greater than in the more hilly fruit and truck land in the eastern part. According to the 1930 census, 95 per cent of the total area of the county is in farms and the average size of farms is 134.5 acres, of which a large proportion is improved land. In the same year there were 1,707 farms in the county, of which 59.3 per cent were operated by owners, 39.8 per cent by tenants, and 0.9 per cent by managers. The most common form of rental is the share-crop system.

The 1930 census reports the average total value of all farm property as $13,998 a farm and the average assessed value of farm land as $104.06 an acre.

In general no very definite system of crop rotation has been followed. On many fields corn and small grain have been grown more or less continuously, and this has resulted not only in the depletion of organic matter and plant food but, on the more rolling soils, in much disastrous erosion. Some fields have been planted to either

corn or wheat for 20 or more years and the yields have declined considerably. Other fields have been seeded to alfalfa for a number of years, or as long as satisfactory yields were produced. Ordinarily this crop has been considered outside the rotation, but in view of the fact that weed pests are more or less troublesome after the fourth or fifth year and that alfalfa stands are more readily obtained when grown only a few years on each field it is apparent that this crop could be used advantageously in a rotation. Red clover is the legume most commonly grown, and its beneficial effects on depleted corn soils is generally understood.

The better farmers have used legume crops to good advantage by including them in the cropping system in regular sequence, devoting to them each year approximately one-fourth of the cultivated land. For the livestock farmer these crops supply an abundance of feed with a high protein content, and the grain farmer may use them to advantage as green manure. Used in either way the productiveness of the soil is maintained at a much higher level. A number of farmers in the western part of the county practice the following rotation: Corn 1 or 2 years, oats 1 year, wheat 1 year, and clover 2 years, or a variation of this, but no definite or specific rotation is in general practice. A few dairy farmers are growing corn 2 years, followed by oats and sweetclover. The last-mentioned crop increases the grazing capacity of the land and makes it more productive for the following corn crop. The potato farmers are using sweetclover as a green-manure crop, mainly to increase the organic matter and nitrogen supply, but no definite rotation is followed.

Commercial fertilizers are not in general use. According to the 1925 Federal census only 18 farms, or 1.2 per cent of all the farms, reported a total of $4,517 expended for fertilizer, or an average of about $250 a farm. Since most farmers handle livestock, they rely on manure to maintain the productiveness of their land. Ordinarily the barnyard manure is applied to cornland and some of it to small fruit and truck crops. A common practice is to seed red clover on the more worn-out land and to turn under the clover in the fall after a good seed crop is harvested. Although the thinner light-brown wheat soils in the southern part of the county seldom receive commercial fertilizer, it is very probable that an application of about 100 or 150 pounds of superphosphate (acid phosphate) to the acre would give profitable results.

The nitrogen supply of the soil is best maintained by the production of leguminous crops and the application of barnyard manure. On the brown upland soils, mainly Knox silt loam, which are used for apple production, a small quantity of nitrogenous fertilizers such as ammonium sulphate and sodium nitrate are used. These supply soluble nitrogen which is deficient in many of the soils. Most of the darker soils having a high organic-matter content are well supplied with available nitrogen and therefore do not ordinarily require treatment of this kind. In general the Marshall and Knox soils are fairly well supplied with phosphorus and potash and up to the present time little return has been realized from applications of phosphatic fertilizers. The dark upland soils with claypan subsoils respond best to applications of these fertilizers.

Up to the present time only a very small amount of lime has been used, most of the soils being well supplied with this constituent, but it is probable that some lime could be used to advantage in the production of alfalfa, red clover, and sweetclover, especially on the upland soils having claypans or moderately heavy subsoils; and some could be used to good advantage on the heavier Missouri bottom soils.

In general, the farmers of Doniphan County have recognized the adaptability of the principal crops to the soils on their farms. The dark-brown or black upland soils with friable subsoils and the loose friable dark-colored terrace and first-bottom soils with similar subsoils are recognized as best suited to corn, clover, and alfalfa. The light-brown hilly soils with loose subsoils and the dark-brown soils with very loose and friable subsoils are best suited to apples and small fruit, berry, and truck crops. The rolling light-brown soils with moderately heavy subsoils and the dark grayish-brown soils with heavy subsoils are recognized as best suited to wheat and oats and poorly suited to alfalfa, and on them clover does not attain its best development. The soils of light texture and color in the first bottoms are used mainly for corn, alfalfa, melons, and garden truck.

Land values vary considerably even on the same type of soil. The steep, hilly timbered land adjoining the Missouri River Valley and some of the inland streams, especially the stony timbered land along Independence and Rock Creeks, constitutes the land of least value because the greater part is too steep for cropping except in isolated patches, and most of it has to be utilized as grazing land. Values of such land range from $15 to $50 an acre. The dark upland soils with friable subsoils have the highest values because they are the most productive and include the least waste land. The value of these soils ranges from about $100 to more than $200 an acre where used for general farming. The same kind of land near towns or in excellent orchards, is held at prices ranging from $300 to more than $400. Ordinarily the light upland soils with friable or moderately friable subsoils range in value from about $75 to $100 an acre, but when in excellent bearing orchards are held for several hundred dollars. The dark and light colored light-textured soils in the Wolf River Valley and on the first and second bottoms of the smaller creeks within the county range in value from about $100 to more than $200 an acre, the higher values being placed on land in orchards. Most of the land in the Wolf River Valley commands a high price on account of an excellent drainage canal which insures good crops each year, but a few small areas of heavier soils here and along Independence Creek, owing to imperfect underdrainage, are of less value.

SOILS AND CROPS

Agriculture is the chief industry in Doniphan County, and the soil is practically the only natural resource. The geographical situation of the county has not favored development of commercial sites, though the short distance to St. Joseph, Mo., presents opportunity for the sale of a large quantity of grain, truck, and fruit crops. The greater part of the land of the county, approximately 85 per cent, is topographically suited to cultivable crops, and about 75 per cent is admirably suited to intensive cultivation.

The chief differences between the alluvial and upland soils are in the depth and the character of either the surface soil or subsoil, their relative degree of friability or plasticity, color, percentage of organic matter, depth to available lime, topographic features, moisture absorbing and retaining capacity, productiveness, adaptability to various crops, and susceptibility to erosion. The character of the soil in different parts of the county and the relief of the land have necessitated different farming systems. Some land is not suited to intertilled crops and must necessarily be utilized for grazing or be left in brush or forest. The proportion of a particular farm used for a given crop is controlled, in part at least, by the relative adaptability of the crop to the soil, but throughout this county as elsewhere soil characteristics do not constitute the sole factor in determining crop distribution.

The upland soils may be divided into (1) light-colored and (2) dark-colored soils. The light-colored soils occur in a belt, from 3 to 6 miles wide and more than 40 miles long, bordering the Missouri River Valley. The land in this belt is thoroughly dissected, and under natural conditions was covered with forest or brush, which was not favorable to a large accumulation of organic matter. The soils, therefore, are light in color, notwithstanding the fact that the virgin or uncultivated soil has a thin covering of leaves and leaf mold. The organic matter derived from leaves of trees does not become thoroughly incorporated with the mineral constituents of the soil material so as to produce a thick layer of dark-colored surface soil, and the thin layer on the surface is not sufficient to make the whole soil dark when it is mixed, in plowing, with the underlying layers of light-colored, generally yellowish-brown or grayish-brown, soil material.

West of the belt of light-colored soils, the soils of the rest of the county are very dark colored, and these soils cover more than half the total area of the county. In a number of places tongues of the dark soils extend eastward along watershed ridges to within 2 miles of Missouri River. These soils, which developed under the influence of a grass vegetation, have become very dark through the continuous decay of grass roots. The dark color is an expression of the high percentage of organic matter in the soils, ranging up to 5 or 6 per cent in the surface layer of these soils, whereas in the light-colored soils it rarely amounts to more than 2 or 3 per cent. This high organic-matter content produces several beneficial effects. It assists the soil in absorbing the sun's heat; it greatly increases the water-holding capacity, thereby insuring considerable protection against crop failure during droughts; it retards destructive erosion on the steeper slopes; and helps to maintain a desirable tilth. Furthermore the organic matter is the chief source of nitrogen which is one of the most important plant foods for growing crops.

The surface soil of the dark-colored upland soils has a very loose granular crumb structure which facilitates penetration of water and the maximum feeding range for crop roots. It allows free aeration, which, in combination with the soil moisture, changes the raw organic and mineral constituents of the soil into more available plant food. Moreover, the granular structure assists in the maintenance of good soil tilth. This group, therefore, is well adapted to all the general farm crops, such as corn, small grains, and legumes, as well as orchard crops.

The alluvial soils, which occupy first and second bottom positions, may likewise be divided into light and dark soils. Their respective colors are due largely to the relative abundance of organic matter in the surface soil. The lighter-colored alluvial soils, which are derived largely from sediments deposited by streams draining light-colored upland soils, occur most extensively in the Missouri River Valley. The dark-colored alluvial soils are derived mainly from sediments brought down from the dark-colored upland soils and occur in the alluvial belts of streams, such as Wolf River, draining the prairie part of the county.

Under the prevailing climatic conditions, the annual precipitation has been sufficient to remove the lime carbonate, originally present in the loess deposits from which the soils have developed, from the surface soil and subsoil to depths ranging from 3 to 5 feet. The rainfall has also been sufficient to prevent the development of any zone of lime carbonate accumulation. The light-colored upland soils contain lime at varying depths, but lime is consistently nearer the surface than in the dark-colored upland soils on account of the gradual erosion of the surface soils, which tends to keep pace with the removal of the lime carbonate from the subsoil. The amount of rainfall absorbed, especially on the upper steeper slopes, is also less on the light-colored upland soils, because the run-off is greater.

The depth to lime carbonate is greater in the dark-colored than in the light-colored alluvial soils because the former have been derived mainly from the surface soils of the dark-colored upland soils. The Missouri River alluvium, which is lighter in color as a rule, is generally composed of materials washed from soils with a higher content of lime carbonate than the dark-colored soils, or from material washed from ravines and gullies whose bottoms and lower slopes lie below the level of the dark-colored soil layer. The alluvial soils nearest the river, or those occupying the lower situations, have a still higher lime content nearer the surface than higher areas of alluvial soils, which have not been flooded recently and have been subjected to leaching for a longer period.

On account of the gentle topographic features of the dark-colored upland soils, they are almost ideal for maximum agricultural utilization. Approximately 97 per cent of the acreage of these soils is under cultivation, and the remainder is chiefly in bluegrass pasture. They support a wide diversification of profitable crops owing to their favorable soil characteristics.

The hilly character of the area occupied by light-colored upland soils is not so favorable for best agricultural utilization. Although the range of crops grown is equal to if not greater than on the dark-colored soils, a lower acreage is favorable to utilization for crops. About 80 per cent of the total acreage is under cultivation. Owing to the comparatively low organic-matter content of these soils, the yields of certain crops are not so high as on the dark-colored upland soils.

All the crops common to the region are grown to greater or less extent on both upland and alluvial soils, but the yields vary considerably. Corn is better adapted to the dark-colored upland and alluvial soils than to the lighter-colored soils. Moreover, the gently undulating features of the dark-colored upland soils allow easier cultivation, and erosion is less severe. Wheat yields, although not

so high on the light-colored as on the dark-colored upland soils, are comparatively higher than those of corn on the light-colored soils. Since the light-colored upland soils are less productive of corn, a smaller proportional acreage is devoted to that crop than on the dark-colored soils. The same is true for oats and barley. Alfalfa is grown successfully on both light and dark colored upland soils and on the alluvial soils. The heavier soils in each group are, however, less favorable for this crop than the medium-textured soils. In general alfalfa is more successful on the dark-colored alluvial soils than on the uplands on account of the better water supply due to the prevailingly high ground-water level. It is better adapted to the dark-colored than to the light-colored upland soils because of the higher nitrogen and organic-matter content and because the underlying substratum has a more abundant water supply and is also well supplied with lime. Red clover is best suited to the dark-colored soils because they are more absorptive and retentive of moisture, contain a higher proportion of organic matter, and still have sufficient lime to meet the requirements of clover.

Orchard crops, berries, and grapes are generally more productive on the light-colored upland soils because these crops do not require a soil having a high organic-matter content but do require a friable, permeable subsoil. These crops are more commonly grown on the steeper slopes in preference to intertilled crops in order to minimize erosion.

The groups of both light and dark colored soils contain several members or soil types. Each soil type differs from the others in the group in profile characteristics, or the characteristics of the several layers of the soil from the surface to a depth of several feet. Some upland soils have deep dark surface soils and very friable, permeable subsoils, and others have similar surface soils but heavy, tenacious subsoils. Some upland soils have light-colored surface soils and are underlain by friable subsoils, whereas others with similar surface soils have moderately tough subsoils. The upland and alluvial soils may be almost identical in color of surface soil but may differ in the texture and color of the lower part of the subsoil. Many of these soils may appear very similar on casual observation, but careful examination brings out highly significant soil differences which may cause pronounced differences in crop adaptations and yields. Other soils may be nonarable due to very inadequate drainage or to very steep topographic features. Inasmuch as some of the several mapped soil types have similar soil characteristics and about the same crop adaptation, the broad soil groups, as previously discussed, may be divided into the following subgroups:

Dark-colored upland soils	1. Soils with friable subsoils. 2. Soils with heavy claypan subsoils.
Light-colored upland soils	1. Soils with friable subsoils. 2. Soils with moderately heavy subsoils.
Dark-colored alluvial soils	1. Soils with friable subsoils. 2. Soils with moderately heavy subsoils.
Light-colored alluvial soils	1. Soils with friable subsoils. 2. Soils with moderately heavy surface soils and upper subsoil layers.

In the following pages the various soils of each group are described and their agricultural utility is discussed. The map accompanying

this report shows the distribution of the soils in the county, and Table 5 gives their acreage and proportionate extent.

TABLE 5.—*Acreage and proportionate extent of the soils mapped in Doniphan County, Kans.*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Marshall silt loam	38,336	15.7	Wabash silt loam	9,152	3.7
Marshall silt loam, gray-subsoil phase	1,088	.4	Wabash silt loam, colluvial phase	8,576	3.5
Marshall silty clay loam	48,576	19.8	Waukesha silt loam	2,624	1.1
Marshall silty clay loam, gray-subsoil phase	8,768	3.6	Wabash silty clay loam	1,024	.4
Shelby clay loam	6,976	2.9	Bremer silt loam	192	.1
Fillmore silty clay loam	832	.3	Ray silt loam	2,624	1.1
Grundy silty clay loam	1,088	.4	Sarpy silt loam	4,096	1.7
Knox silt loam	56,576	23.1	Sarpy very fine sandy loam	3,136	1.3
Knox silt loam, steep phase	8,640	3.5	Sarpy silty clay loam	2,240	.9
Newtonia silty clay loam	10,240	4.2	Sarpy clay	5,504	2.2
Newtonia silty clay loam, stony phase	6,144	2.5	Sarpy clay, poorly drained phase	960	.4
Knox silt loam, heavy-subsoil phase	12,032	4.9	Jackson silt loam	768	.3
			River wash	4,928	2.0
			Total	245,120	

DARK-COLORED UPLAND SOILS WITH FRIABLE SUBSOILS

The dark-colored upland soils with friable subsoils are the most extensive soils in the county and are the most important agriculturally. The general prosperity of the inhabitants depends largely on the proper utilization and conservation of these soils which include Marshall silt loam and Marshall silty clay loam, each with a gray-subsoil phase, and Shelby clay loam. These soils occupy a total area of 162.1 square miles, or 42.4 per cent of the total area of the county.

On the Marshall soils, corn is the predominant crop. Its yearly average acreage is more than double that of wheat, more than four times that of oats, and six times that of alfalfa or of red clover. Sweetclover is gaining in acreage, and at the present time its acreage is about one-sixth of that in corn. The combined acreage of all tame hay is approximately three-sevenths of that in corn. The corn acreage is very uniformly distributed on these soils. The silt loam soils are generally better suited to corn. The legumes succeed equally well on the silt loam and the silty clay loam soils. Wheat and oats are generally favored on the silty clay loams, but the yields differ little if any from those produced on the silt loams. Ordinarily, yields of corn range from 40 to 60 bushels an acre and yields as high as 75 or more bushels are frequently obtained under good farm management; oats yield from 25 to 45 bushels, wheat from 18 to 35 bushels, red clover from 1½ to 2½ tons in two cuttings, and alfalfa from 3 to 5 tons an acre each season with the usual four cuttings. Crops produce good yields because of the smooth relief, the excellent drainage and underdrainage, the high percentage of organic matter in the thick dark-colored surface layer, the friable and permeable character of the subsoil, and the large supply of lime for the needs of legumes in the lower subsoil layer.

Because of the very friable and permeable subsoil, small fruits, berries, and orchard crops do well. These are grown mainly on Marshall silt loam in the vicinity of Troy. The other soils are also suited to such crops but are not so favorably situated with respect to

marketing facilities. Orchard crops, especially apples, pears, and cherries, do best on the areas of Marshall silt loam which occur in proximity to the Knox soils. In such places the subsoil is slightly more friable and permeable than at points more distant from the Knox soils and affords a condition favorable for the maximum root development of fruit trees.

Marshall silt loam.—Marshall silt loam is the most productive upland soil in Doniphan County. In Kansas it occurs mainly in the tier of counties bordering Missouri River, chiefly north of Kansas City. It has an unusually wide range of crop adaptation, not surpassed by any other upland soil within the Corn Belt. The crops produced commercially include not only corn, wheat, oats, barley, clovers, timothy, and alfalfa, but orchard crops, chiefly apples, pears, and cherries, and such garden truck crops as grapes, strawberries, raspberries, blackberries, and various vegetables. In Doniphan County this soil is typically developed on the broad gently sloping divides having very mild relief. (Pl. 1, A.) The slope is sufficient to insure excellent drainage but not so pronounced as to cause serious erosion.

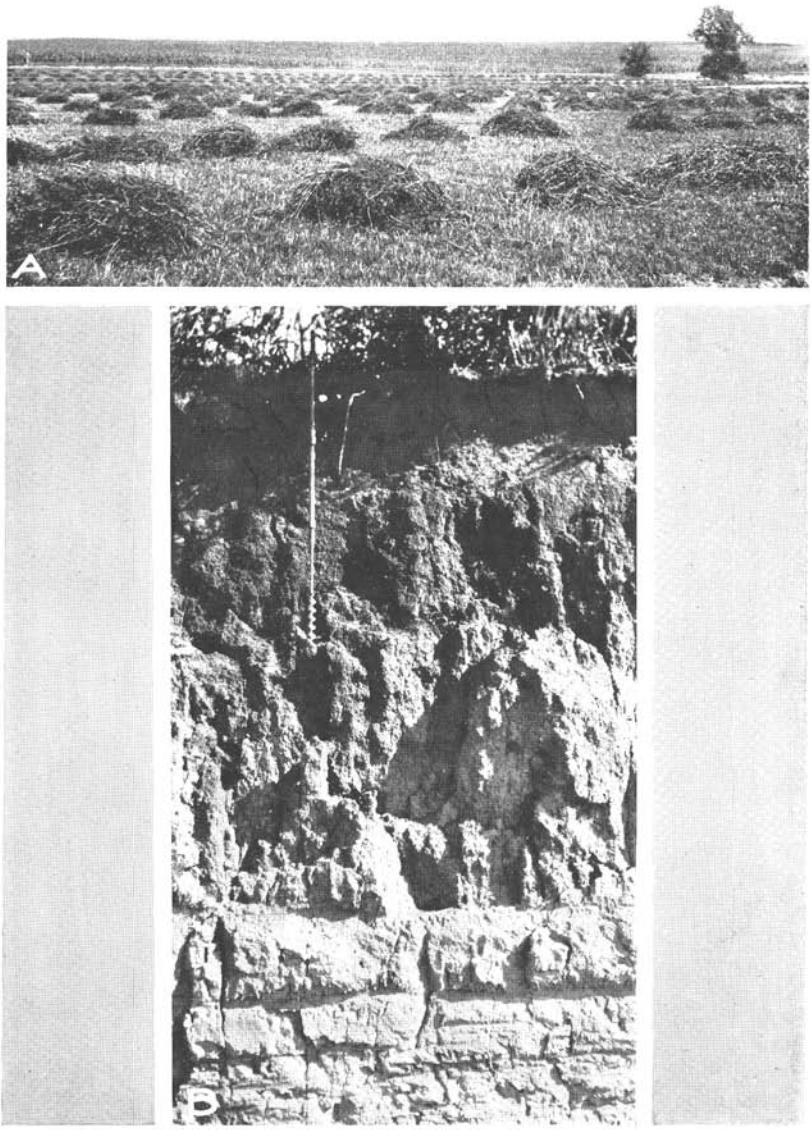
The surface soil of Marshall silt loam consists of very dark-brown or almost black porous silt loam to a depth ranging from about 12 to 16 inches, and it is underlain by a lighter-brown transitional layer which extends to a depth of 20 or 24 inches. The color gradually becomes lighter brown with depth, owing to the gradual decrease in the organic-matter content. The subsoil is light brown, grayish brown, or buff and is considerably heavier than the surface soil, ranging from heavy silt loam to silty clay loam, but it is rather friable and nowhere approaches a claypan. The lower subsoil layer, lying at a depth ranging from 30 to 36 inches, may be either heavy silt loam or silty clay loam, but invariably is a little lighter in texture than the upper subsoil layer. (Pl. 1, B.) The underlying buff-colored substratum extends from a depth of 6 or 8 feet to 40 or more feet.

Table 6 shows the hydrogen-ion concentration, or pH value, of Marshall silt loam. The pH units are a convenient expression of the acidic or basic reaction of a soil. A pH value of 7 denotes that the soil is strictly neutral. Decreasing values of these units from this point indicate increasing acidity or hydrogen-ion concentration, and likewise values greater than pH 7 indicate increasing alkalinity. It will be seen that Marshall silt loam is slightly acid to a depth of 80 inches. The surface soil is the most acid layer, but even this can not be described as highly acid, and the material lying between depths of 45 and 80 inches is almost neutral. Below a depth of 80 inches the material ranges from neutral to alkaline.

TABLE 6.—*pH determinations of Marshall silt loam in Doniphan County, Kans.*

[1:2 soil-water ratio]

Sample No.	Depth in inches	pH value
381925	0–16	5.79
381926	16–45	5.89
381927	45–80	6.44



A, Characteristic gently undulating relief of Marshall silt loam (second cutting of red clover for seed in foreground); B, profile of unweathered Marshall silt loam

A, Characteristic relief of Knox silt loam (vineyard in foreground and apple orchard in background); B, profile of unweathered Knox silt loam

Marshall silt loam, gray-subsoil phase.—Marshall silt loam, gray-subsoil phase, is identical with typical Marshall silt loam to a depth ranging from 30 to 36 inches. Below this depth the soil material is as heavy as the material in the upper part of the subsoil and does not grade into lighter-textured material with increase in depth, as in the typical soil. The texture is silty clay loam or silty clay and, in places, clay occurs at a depth ranging from 6 to 8 feet. The color below a depth of 36 inches is light grayish brown or olive gray in contrast to the light-brown or buff color of typical Marshall silt loam. This difference, however, has little agricultural significance.

Marshall silty clay loam.—Marshall silty clay loam is very similar to Marshall silt loam in soil characteristics except that its surface soil is heavier, being silty clay loam rather than silt loam. In relief, however, it is consistently more sloping. The sloping surface has caused increased erosion, which has produced a variable surface appearance. The slopes are not steep, and all the land except strips along some of the small crooked creeks and drainage ways can be cropped. The continuous cultivation and intermixing of the surface soil with the underlying subsurface soil and, in places, with the subsoil and the removal of various amounts of the black surface soil through erosion have made the surface soil lighter in color, generally brown rather than very dark brown or deep black, and have given rise to a heavy silt loam or silty clay loam soil, with a lower content of organic matter. The zones of transition between areas mapped as Marshall silt loam and those mapped as Marshall silty clay loam are broad, and the boundary lines shown on the map are more or less arbitrarily drawn. Under present farming practices, however, the areas differentiated as silty clay loam will gradually become more obvious because of the yearly loss, by erosion, of varying amounts of the present cultivable soil. The lower part of the subsoil and the substratum of Marshall silty clay loam are almost identical with corresponding layers of Marshall silt loam.

Marshall silty clay loam, gray-subsoil phase.—Marshall silty clay loam, gray-subsoil phase, is almost identical with Marshall silty clay loam in topographic configuration and in surface soil and subsoil characteristics. The lower part of the subsoil is identical with that of Marshall silt loam, gray-subsoil phase.

Shelby clay loam.—Shelby clay loam may be included in the same group as the Marshall soils since it is a dark-colored soil. It is intermediate in characteristics, however, between the soils of the claypan group and those of the friable-subsoil group. Its surface covering is thinner than that of the other soils of the group, and some areas in forest or brush are not so decidedly dark in color. Its occurrence is restricted to slopes along small drains emptying into Wolf River in the western part of the county and along Independence Creek. This soil has a total area of 10.9 square miles.

The surface soil of virgin areas of Shelby clay loam consists of dark-brown rather heavy loam to a depth of 8 to 12 inches, underlain by lighter-brown silt loam to a depth of about 15 inches. To a depth of about 24 inches the subsoil is light-brown clay loam material which merges gradually into light yellowish-brown clay loam reaching its maximum heaviness at a depth of about 36 inches. The soil has developed from glacial material and contains various amounts of

sand, gravel, and bowlders intermixed with the more dominant rather heavy clay. Sand and gravel are more abundant in the lower subsoil layer, and more reddish-brown and rust-brown coloring is present in places. In plowed fields the color of the surface soil ranges from dark brown to light brown. The older cultivated fields, having been subjected to erosion for longer periods, have had the upper dark-colored layer largely removed, and more or less of the subsoil is mixed with the surface soil. In a few small areas, which occur from 1½ to 2½ miles southeast and 2 miles southwest of Leona, the soil consists of a thin covering of silty clay loam underlain at a depth ranging from 10 to 24 inches by rather light bluish-gray shale. In a few places the shale is exposed at the surface. These included areas are used almost entirely as pasture.

Drainage of this soil ranges from good to excessive, and on old rather sloping fields the soil erodes easily. The prevention of gullying is a difficult matter.

The productive capacity of Shelby clay loam is not so high as that of the Marshall soils, but the same crops are grown. Erosion has been more severe because of the more sloping surface. It is estimated that 90 per cent of Shelby clay loam is under cultivation, and the remainder is in forest, brush, or pasture.

DARK-COLORED UPLAND SOILS WITH CLAYPAN SUBSOILS

The dark-colored upland soils with claypan subsoils include Fillmore silty clay loam and Grundy silty clay loam. They occur in the extreme southwestern part of the county and comprise a total area of only 3 square miles.

Fillmore silty clay loam occurs on the nearly flat interstream divides where erosion has not disturbed the surface, and Grundy silty clay loam occurs on the gentle slopes toward the streams. Here the moisture has not been sufficient to produce a dense claypan, and erosion has removed more or less of the black surface soil.

In outward appearance these soils closely resemble Marshall silt loam, gray-subsoil phase, and Marshall silty clay loam, gray-subsoil phase. The dark-brown or black color is duplicated, the consistence of the surface soil is loose, and the same soft granular or crumb structure is present.

The stiff subsoils of the Grundy and Fillmore soils greatly retard downward percolation of surface water and cause a more generally acid condition of both surface soils and subsoils than occur in the Marshall soils. Liming of these heavy soils would, in most places, prove beneficial. Sweetclover, grown as green manure, not only increases the organic-matter content and available nitrogen but the large vigorous roots tend to open the stiff lower subsoil material to some extent, and later, after the roots decay, the downward percolation of water is more rapid.

Almost all this land is in cultivation. A few small areas are utilized for hay or pasture land. On these soils the wheat acreage is greater than the corn acreage. The stiff subsoil does not seriously affect wheat yields as it does corn yields, which are often materially reduced on account of a greater susceptibility to both drought and excessive moisture. When the rainfall is well distributed good yields are produced, corn yielding from 25 to 50 bushels, wheat from 12 to 25 bushels, oats from 15 to 35 bushels, and hay from 1 to 2½ tons

to the acre. Commercial orchards, especially of apples, pears, and cherries, are not suited to these soils, although enough fruit for home use can be produced. The heavy subsoil obstructs downward root penetration, thereby preventing rapid vigorous root development, retards the escape of water in rainy seasons, and prevents the proper retention of moisture in droughty periods.

Fillmore silty clay loam.—The most striking feature of Fillmore silty clay loam is in the subsoil. At a depth that may vary from 12 to 16 inches the very dark grayish-brown or black silty clay loam topsoil grades through a layer of intermediate texture, from 2 to 6 inches thick, into a heavy clay subsoil. The upper part of this claypan is dark colored, very dense, and compact. It ranges in thickness from 4 to 10 inches, but over the greater part of the area it averages about 8 inches. The lower part of this heavy layer is stiff, plastic clay. The color gradually changes downward and at a depth of about 26 inches becomes olive gray with rust-brown stains. Below depths ranging from 40 to 50 inches the material is light olive-gray clay, but the texture is not so heavy as in the claypan layer.

Grundy silty clay loam.—Grundy silty clay loam differs from Fillmore silty clay loam in its slightly more rolling relief and in its less heavy and dense claypan layer. The surface soil is similar in appearance to that of the Fillmore soil where erosion has not been too severe, but in many places the slope of the land has facilitated erosion, thereby diminishing the thickness of the surface layer. Excessive erosion is more harmful on this soil than on the corresponding soil of the Marshall series, because when most of the surface material is removed not only is a large part of the organic matter lost but the subsoil is left near the surface within reach of the plow. The stiff underlying subsoil makes plowing difficult, the tilth is impaired, the moisture absorbing and retaining capacity is diminished, and root penetration is retarded. As a result, crop yields in dry years are far below those obtained on the Marshall soils.

LIGHT-COLORED UPLAND SOILS WITH FRIABLE SUBSOILS

The light-colored upland soils characterized by friable, permeable subsoils are important but are not cultivated so extensively as the dark-colored upland soils because of their rolling or steep relief. Under this group are included Knox silt loam and its steep phase, the total areas of which are 88.4 and 13.5 square miles, respectively.

Knox silt loam.—Knox silt loam differs from Marshall silt loam in having a light-colored surface soil containing a much lower percentage of organic matter. This soil invariably occurs on rougher land than does the Marshall soil. (Pl. 2, A.) It is locally referred to as "yellow clay," although even the heaviest part of the subsoil is rather friable and contains only a comparatively small proportion of clay. As typically developed west of the Missouri River bluffs, the topsoil in virgin forested areas consists of a 4 to 8 inch layer of brown friable silt loam underlain by lighter-brown silt loam. At a depth ranging from 10 to 15 inches this material grades into light-brown or yellowish-brown silty clay loam, and below a depth ranging from 22 to 26 inches the material is grayish-brown or grayish-yellow silt loam which continues to an undetermined depth. (Pl. 2, B.)

In cultivated fields the topsoil has been so mixed with the underlying layers and so thinned and depleted through erosion that not

only the color but also the texture, which ranges from silt loam to silty clay loam, is rather variable. The older cultivated fields are in general more spotted, varying widely in details of color and texture, but the variations are so intricately mixed and in such patchy association that separation could not be satisfactorily made on a small-scale map. In places erosion has cut through the heavier former subsoil, and the present surface soil and subsoil are more silty. Such areas occur about midway on some of the steeper cultivated slopes. Soil loss due to erosion has been greater on this soil than on any other in the county. In fact a number of small fields have been abandoned for a number of years for this reason and have reverted to bluegrass pasture. (Pl. 3, A.) Many of the steeper slopes, when cleared, are severely injured by erosion especially those used for growing corn. (Pl. 3, B.) A few small areas which occur 1 mile northeast and 1 mile southeast of Sparks consist of partly reworked material washed from the higher slopes and redeposited on the lower slopes. The color is somewhat darker than typical, and the depth of the soil is variable. Lime carbonate occurs sparingly or not at all to a depth of 24 inches but is rather abundant below this depth, this being the lime carbonate of the original loess material. Where lime carbonate occurs near the surface it indicates that erosion has removed the surface soil and the surface has been lowered to the original material still unleached of its lime.

It is estimated that between 90 and 95 per cent of Knox silt loam is cultivated, and the remainder is in either grass or timber. Corn is the crop most extensively grown, but the yield is commonly lower than on the Marshall soils. Red clover and alfalfa succeed because of the available lime in the soil, but in dry years difficulty is experienced in obtaining a stand of these legumes. Orchard fruits, especially apples, pears, and cherries of high quality, are produced on this soil. Peach orchards are far less numerous than formerly, due to late-spring frost hazards. Grapes are admirably adapted to this soil, even where the land is rather steep for other crops. Strawberries, blackberries, raspberries, and many vegetables are well adapted and are grown as cash crops for St. Joseph and other markets.

Knox silt loam, steep phase.—Knox silt loam, steep phase, differs from Knox silt loam mainly in topographic position. The steep phase includes very rolling, steep slopes along the bluffs of Missouri River which have always been undesirable for cultivated crops. A few narrow protruding ledges of limestone occur on some slopes. Approximately 85 per cent of this steep soil is in timber. (Pl. 3, C.)

The soil characteristics of the phase are essentially the same as those of the typical soil. In most places the surface soil is thinner, ranging from 4 to 8 inches in depth, and the color is a slightly lighter shade of brown, indicative of a lower content of organic matter. The subsurface soil and subsoil are similar to those of the typical soil, and in most places both surface soil and subsoil contain a higher proportion of very fine sand.

The same crops as those mentioned for the typical soil are adapted to the steep phase, but the difficulty of clearing, plowing, and cultivating the steep slopes has, in the past, been unfavorable to extensive agriculture. Such crops as grapes, raspberries, and strawberries, which can be contour cultivated, can be grown more advantageously, however. Apple or pear orchards with cover crops to minimize erosion are

also favored. A few farmers have cleared or partly cleared these steep areas and are utilizing them as pasture for livestock, especially sheep. Approximately 15 per cent of the soil is under cultivation, the remainder being covered with a natural forest growth consisting mainly of white, bur, red, and laurel oaks, hickory, elm, ash, walnut, cherry, honeylocust, and sycamore.

LIGHT-COLORED UPLAND SOILS WITH MODERATELY HEAVY SUBSOILS

Associated with the Knox soils are soils which have similar topographic features but have heavier subsoils. They include Newtonia silty clay loam and its stony phase, and Knox silt loam, heavy-subsoil phase.

The surface soils of these soils have been largely removed by erosion, and they vary greatly in texture but are comparatively heavier than the surface soil of Knox silt loam. The rolling relief of these soils and the heavy surface soil do not allow rapid penetration of rainfall. The soil is more or less droughty and erosion is severe. These conditions have favored small-grain production because such crops can be matured before the hot dry weather has a chance to seriously affect the yield. Corn, however, is still grown to a considerable extent. Vineyards and orchards are rather scarce, partly because they are not so well adapted to these soils as to Knox silt loam, and partly because the areas are not so advantageously situated with regard to markets. In places where the slopes are excessively eroded, the land has become uncultivable and has been allowed to revert to bluegrass. Yields of small grains are similar to those on Knox silt loam, but yields of corn are lower, ordinarily ranging from 25 to 40 bushels an acre. Alfalfa and red clover do not do so well as on the Knox and Marshall silt loams. Sweetclover is more extensively grown than formerly, and its acreage could doubtless be increased to advantage.

Newtonia silty clay loam.—The surface soil of Newtonia silty clay loam is very similar to that of Knox silt loam. It consists of brownish-gray heavy silt loam or silty clay loam grading at a depth ranging from 4 to 8 inches into light-brown silty clay loam with a faint red tint. The subsoil grades at a depth of 10 or 12 inches into slightly reddish-brown silty clay which extends to a depth ranging from 30 to 36 inches. Numerous rust-brown or reddish-brown stains and soft concretions are present in various quantities. The lower subsoil layer is splotched with light brown and gray and is decidedly heavier than the lower subsoil layer of the Knox soil. Erosion has eliminated a large part of the original surface layer, and cultivated fields range in color from light brown to reddish brown, the last-mentioned color indicating small areas where erosion has been most severe. The less-eroded areas, occurring on narrow ridges, are silt loam in texture but are too inextensive to justify a type separation. Small slabs of limestone may occur on the upper or lower part of the slopes and in places may be mixed through the soil. The main areas of Newtonia silty clay loam are in the southern part of the county along Rock and Independence Creeks. A total of 16 square miles is mapped, practically all of which is cultivated.

Newtonia silty clay loam, stony phase.—Newtonia silty clay loam, stony phase, occurs chiefly along Independence and Rock Creeks in the southern part of the county and along a few rugged slopes in the eastern part. These areas comprise a total of 9.6 square miles.

This stony soil includes land unsuitable for cultivated crops, and less than 2 per cent of the total area is under cultivation. It occupies steep stony slopes where limestone outcrops in such abundance as to render the land unfit for cultivation except in a few isolated patches or very narrow strips between limestone ledges. The soil varies in texture, color, depth, and proportion of limestone fragments contained. The surface soil may be dark-brown or grayish-brown silt loam, silty clay loam, or silty clay. It is underlain at depths ranging from 3 to 12 inches by rather heavy yellowish-brown or reddish-brown silty clay intermixed with small or medium-sized limestone slabs. In places, similar soil material may attain a depth of 2 or 3 feet before limestone rock is reached.

Land of this kind is utilized for grazing purposes. It may be covered with a heavy or sparse natural forest growth, or it may be almost barren. More or less of the forest growth is being cut from year to year for fuel and posts, and the land is thus cleared, which makes it better for grazing livestock.

Knox silt loam, heavy-subsoil phase.—The surface soil of Knox silt loam, heavy-subsoil phase, is identical with that of Knox silt loam. At a depth ranging from 8 to 15 inches the material is silty clay loam which grades between depths of 15 and 24 inches into silty clay having a slight red tint. At a depth of about 40 inches the brown friable subsoil so characteristic in the Knox silt loam is present.

DARK-COLORED ALLUVIAL SOILS WITH FRIABLE SUBSOILS

The group of dark-colored alluvial soils with friable subsoils includes Wabash silt loam and Wabash silt loam, colluvial phase, of the first bottoms and Waukesha silt loam of the second bottoms or terraces. These soils constitute a total area of 31.8 square miles.

Wabash silt loam occurs chiefly on the first bottoms of Wolf River and along all the main creeks of the county but not on the first bottoms of Missouri River. The colluvial phase of this soil occurs on the small narrow first bottoms of small streams. Waukesha silt loam is best developed along Peters, Brush, and Smith Creeks.

Areas of these soils are nearly level, but ordinarily the slope is sufficient to insure good surface drainage. The large drainage canal along Wolf River provides adequate drainage to insure successful crop production in Wolf River Valley. Waukesha silt loam is well drained. It occupies situations from 10 to 20 feet above the Wabash soils and therefore is not subject to overflow. The Wabash soils are rarely covered by overflow waters except in small low-lying areas.

It is estimated that about 98 per cent of Wabash silt loam, 80 per cent of Wabash silt loam, colluvial phase, and 96 per cent of Waukesha silt loam are under cultivation. Many areas of Wabash silt loam, colluvial phase, are very narrow and are traversed by crooked ditches. Such areas can best be utilized for grazing purposes.

These soils are not surpassed in productiveness by any other alluvial soils in the central West. They are composed of wash from the adjoining dark-colored upland soils, and have a high content of organic matter. Their topographic position and high organic-matter content have rendered the soils very absorptive and very retentive of moisture. Corn, therefore, is admirably well suited to these soils, and the yearly corn acreage surpasses that of all other crops combined. Yields of corn range from 40 to 70 bushels, and some fields are reported to

produce 100 or more bushels to the acre. Corn is grown on many fields year after year with an occasional rotation to a small-grain or leguminous crop. Many fields which have been cropped to corn almost continuously from 10 to 20 years still produce excellent yields. Wheat yields range from 18 to 35 bushels and oats from 25 to 45 bushels an acre. Small grains have a tendency to lodge unless the spring season is unusually dry. Alfalfa and red clover are also grown, but their proportional acreages are not so high as on the dark-colored upland soils. Ordinarily yields are about equal on soils of both groups; in dry years they are higher on the dark-colored alluvial soils with friable subsoils.

Wabash silt loam.—The surface soil of Wabash silt loam consists of dark grayish-brown or black friable mellow silt loam, from 14 to 20 inches deep. The subsoil is light-brown or grayish-brown silty clay loam or silty clay but nowhere approaches a claypan. Both topsoil and subsoil have a high organic-matter content. In places, along the lower courses of small drains which empty into Wolf River, the dark soil may extend to a depth of 3 feet with little variation other than a slight increase in the clay content below a depth of 20 inches. Included with mapped areas of this soil, along the bends of Independence Creek in the southern part of the county, are a few very narrow strips of sandy soil material which grades from loam or sandy loam to very fine sandy loam.

Wabash silt loam, colluvial phase.—The colluvial phase of Wabash silt loam varies greatly because of differences in accumulations from the adjoining uplands. It is essentially like Wabash silt loam in color, but the lower part of the subsoil in many places is more friable.

Waukesha silt loam.—Waukesha silt loam is almost identical in appearance with Marshall silt loam of the uplands. Generally the silt loam surface soil has a browner shade than the Wabash soils, and the subsoil at a depth ranging from 16 to 22 inches is either grayish brown or yellowish brown, whereas the subsoils of the Wabash soils are more consistently grayish brown at the lower depths. The subsoil is more friable than in the Wabash soils, generally being silty clay loam in texture. The areas mapped along Independence and Brush Creeks have a slightly heavier lower subsoil layer than elsewhere in the county and in this respect are very similar to the Wabash soils.

DARK-COLORED ALLUVIAL SOILS WITH MODERATELY HEAVY SUBSOILS

The dark-colored alluvial soils with moderately heavy subsoils include Wabash silty clay loam of the first bottoms and Bremer silt loam of the terraces. These soils comprise a total area of only 1.9 square miles and therefore are comparatively unimportant.

Wabash silty clay loam occurs along Wolf River, the main areas being northeast of Severance, and Bremer silt loam occurs in a few isolated areas along Independence Creek in the southern part of the county. These soils occupy smooth more or less imperfectly drained areas.

Approximately 75 per cent of these soils is under cultivation, being cropped mainly to corn or alfalfa, and few fields remain in grass. Yields of corn, as well as of other crops, are lower and less dependable than those produced on Wabash silt loam, because of the unfavorable soil texture and drainage.

Wabash silty clay loam.—The surface soil of Wabash silty clay loam consists of dark grayish-brown or black silty clay loam from 10 to 14 inches deep. The subsoil is heavy rather impervious silty clay or clay. The lower part of the subsoil is dull dark gray or grayish black, in most places mottled with rust-brown spots, and it contains iron stains and concretions. It is noncalcareous. Underdrainage is imperfect.

Included with this soil in mapping is an area of Wabash clay, 2 miles southwest of Fanning, and a small area which averages silty clay in texture 1 mile northeast of Severance. The soils in these areas are very heavy and, because of their poor surface drainage, are utilized as pasture.

Bremer silt loam.—The surface soil of Bremer silt loam is similar to that of Wabash silty clay loam, but the subsoil contains lime at a depth ranging from 24 to 36 inches. The subsoil below a depth of 26 inches is rather plastic and impervious and generally has a decided olive-gray color.

LIGHT-COLORED ALLUVIAL SOILS WITH FRIABLE SUBSOILS

The light-colored alluvial soils with friable subsoils include Ray silt loam, Sarpy silt loam, Sarpy very fine sandy loam, and Sarpy silty clay loam. They cover a total area of 18.9 square miles.

The Sarpy soils occupy first bottoms along Missouri River, and Ray silt loam is developed along Wolf River, and Cedar, Squaw, Mill, and Mission Creeks in the northwest part of the county. These soils have good surface drainage and underdrainage and are seldom completely covered by overflow.

All the soils of this group occur in smooth areas many of which are flat and only locally are billowy or hummocky. Near some of the bends old overflow deposits have formed terracelike bodies which lie from 8 to 12 feet above the lower levels. Most of the Ray silt loam areas occurring in the Missouri River bottoms nearest the bluff line are on alluvial-fan slopes built up by deposits from overflow water of small streams.

It is estimated that 98 per cent of the Ray silt loam and about 96 per cent of each of the other soils is under cultivation, and the remaining land is in pasture. Corn is the most important crop grown. Yields on Ray silt loam and Sarpy silt loam range from 40 to 70 bushels an acre, and on the other soils of this group from 35 to 60 bushels. The total acreage of corn is more than the total acreage of all other crops combined. Some wheat is grown, and the yields range from 18 to 30 bushels an acre. Alfalfa, which is grown rather extensively, yields from 2½ to 4 tons of hay to the acre, the yields on Ray silt loam being comparatively higher than those on the other soils. No liming has been necessary for alfalfa on these soils.

Some trucking is practiced in the vicinity of Elwood, mainly on Sarpy very fine sandy loam. Berries, potatoes, melons, and various early truck crops are grown with moderate success, and a ready market is available just across Missouri River at St. Joseph, Mo.

Ray silt loam.—Ray silt loam consists of light-brown or buff-colored silt loam underlain at a depth ordinarily ranging from 6 inches to 3 feet by brown or dark-brown heavy silt loam or silty clay loam representing old alluvium or buried Wabash soils. Large quantities of

buff-colored soil material from the highly erosive Knox soils has gradually accumulated over the lower-lying dark-colored Wabash soils. No doubt some of the areas which are now shown on the map as Wabash soil may ultimately be covered sufficiently with lighter-brown soil material to convert them into Ray silt loam. (Pl. 3, C.)

Sarpy silt loam.—Sarpy silt loam, which occurs in the Missouri River Valley proper, is not underlain by dark-colored material, differing in this respect from the Ray soils. It consists of light-colored soil material deposited by Missouri River and other large streams.

The surface soil of Sarpy silt loam is more grayish brown than that of the Ray soil and is underlain, at a depth ranging from 10 to 24 inches, by material which is generally a little lighter in texture than the surface soil. The depth and thickness of the surface layer and the underlying layers depend on the distance from Missouri River and the duration of the past overflow periods.

Sarpy very fine sandy loam.—The surface soil of Sarpy very fine sandy loam is yellowish gray, brownish gray, or grayish brown, and it is underlain at a depth ranging from 10 to 30 inches by silt loam, silty clay loam, or, in low-lying situations, by clay, which, in turn is underlain by layers of almost any combination of textures. The underlying layers may change gradually or rather abruptly into each other and may vary from a few inches to 10 or even 15 inches in thickness.

Sarpy silty clay loam.—Sarpy silty clay loam is almost identical with Sarpy silt loam except that the texture of the surface soil is slightly heavier.

LIGHT-COLORED ALLUVIAL SOILS WITH MODERATELY HEAVY SURFACE SOILS AND UPPER SUBSOIL LAYERS

The heavier-textured light-colored group of alluvial soils inlcudes Sarpy clay, with its poorly drained phase, and Jackson silt loam. River wash, a miscellaneous alluvial material, is also placed in this group. These soils occupy a total area of 19 square miles. The Sarpy soils and river wash occur only on the Missouri River first bottoms and Jackson silt loam only on second bottoms along Independence Creek in the southern part of the county.

The soils of this group have a wide range in agricultural value. It is estimated that 95 per cent of Jackson silt loam and only about 5 per cent of Sarpy clay, poorly drained phase, is cultivated. Corn and wheat, which are the chief crops grown, occupy an acreage almost equal to the combined acreage of all other crops. Yields of corn range from 30 to 60 bushels to the acre, the yields on Sarpy clay being less certain on account of the heavy texture and rather imperfect surface drainage and underdrainage. Wheat yields from 18 to 30 bushels and alfalfa from 2 to 3 tons an acre. Comparatively little alfalfa is grown at the present time because of the uncertainty of obtaining good stands and yields. Soils mapped as Sarpy clay and Jackson silt loam are, in most places, more or less acid to a depth ranging from 3 to 4 feet, and on newly seeded alfalfa fields the individual taproots, in many places, are unable to penetrate the heavy clay and reach the underlying limy soil material before the stand has been thinned by weeds and grass. Sarpy clay formerly produced excellent yields of alfalfa, but of late years the crop has been somewhat unsatisfactory. An application of 2 or 3 tons of finely ground limestone

to the land and careful seed selection would probably insure successful yields.

Sarpy clay.—Sarpy clay consists of rather dark brownish-gray or dark olive-gray moderately heavy clay which extends downward to a depth ranging from 24 to 30 inches. The lower subsoil layer is rather light-colored olive-gray clay and grades into silt loam, silty clay, or very fine sandy loam similar to the material underlying all soils of the Sarpy series.

Sarpy clay occupies comparatively large areas and in most places the surface relief is sufficient to allow slow surface drainage, but the heavy surface soil and upper part of the subsoil restrict underdrainage. Sarpy clay generally occupies a higher level than any of the associated soils except Sarpy silt loam. A few small areas, however, lying adjacent to Sarpy clay, poorly drained phase, are approximately from 6 to 10 feet lower and are frequently overflowed.

Sarpy clay, poorly drained phase.—Sarpy clay, poorly drained phase, consists of heavy clay, too poorly drained to allow cropping unless artificially drained. Various water grasses, rushes, and willow constitute the more common natural vegetation.

Jackson silt loam.—Jackson silt loam has a brown or brownish-gray surface soil underlain, at a depth ranging from 10 to 14 inches, by light-brown or slightly reddish-brown silty clay loam. The lower part of the subsoil is moderately friable silty clay loam or silty clay and contains some gray mottlings.

River wash.—At the present time areas mapped as river wash have little agricultural significance. Such areas include low-lying land in the immediate proximity of Missouri River, generally from 2 to 8 feet above the normal water level of the river. They range in texture from sand to clay, in color from light brownish gray to dark olive gray, and in relief from flat to billowy. Numerous variations occur in both horizontal and vertical sections of the soil profile. The land is strewn with uprooted trees and piles of driftwood, and stagnant water stands in the depressions nearest the river. The soil in most places supports a growth of young cottonwood and willow, but the newly deposited sand bars or sand flats bordering the river are barren. As the trees increase in size and overflow deposits accumulate the surface level is raised and areas more desirable for cultivation are formed. A number of small isolated patches are now utilized in the production of melons, corn, potatoes, and garden truck and produce excellent yields, although the risk from overflow has prevented any large areas from being cropped.

EROSION

Erosion is not only the most serious menace confronting many of the farmers of Doniphan County at present, but will be to those who will farm the land in the future. About half the land of the county is moderately rolling or steep, and at least three-fourths of it is very susceptible to erosion, as the soils are of loessial material which is very susceptible to washing on account of its loose, silty, incoherent character. The almost continual cropping of the soil to corn and small grain has greatly facilitated erosional activity, because when corn is grown on sloping land the farmers have a practice of making a miniature drain or furrow up and down the slope across the listed

rows so that the minimum of small corn will be washed out or covered by spring rains. These cross furrows are made at intervals ranging from 30 to 60 yards. This practice, which has been in use for several decades, has greatly accelerated wastage, through erosion, of the richer surface soils and tremendous amounts have been removed. Many fields have begun to gully, and some of the older fields have long been abandoned and are utilized for grazing purposes only. Such fields are less absorptive of moisture, and in dry periods they are about as droughty as stony land and their value is lowered from 50 to 75 per cent.

Farmers who have planted their corn with the rows extending along the sides of the slopes or around the slopes have not been forced to abandon their fields but have lost enormous amounts of soil material by sheet erosion. Some fields have been lowered more than 3 feet, and in places the heavier subsoil material has been completely removed, erosion having passed through even this layer. In general, erosion has so thinned the surface layer on the rolling land that, in plowing, a thin layer of the heavier subsoil is turned up each year. When the mellow topsoil is removed, much of the valuable supply of nitrogen and organic matter is lost. The exposed subsoil is less permeable and less absorptive of moisture, and far less productive than the surface soil, and the generally good tilth of the soil is greatly impaired. In this condition plant foods are not only reduced but are more or less unavailable in their present form. The profits which accrue from tilling such land are usually very meager. To rebuild the land takes time, money, and work. Although apples and other fruits do not require such large quantities of organic matter as does corn, they require more than is present after the land is severely eroded, and orchards which are set out on badly eroded fields never have the vigor or productive capacity of those which are set out on land where erosion has not greatly thinned the surface soil.

The construction of terraces would greatly minimize erosion on the sloping areas. The broad Mangum terrace would probably be best suited for the sloping dark upland soils but this form of terrace would not be suitable for the steeper light-colored soils. The steeper slopes would require much less width of base than the 20 to 30 foot base of the Mangum terrace and could not, on many slopes, be cultivated over their top, as can be done with the Mangum terrace. The distance between each terrace would necessarily have to be short—from about 10 to 20 yards—and the rows would have to be planted in the direction of the terraces and be contour cultivated. Most of the terraces should have a fall of 4 to 6 inches a hundred feet and the difference in elevation between the terraces should be about 5 feet. The slow movement of water along the terrace serves to allow the sediments to settle, and only a comparatively small amount of the eroded material has a chance to be removed from the field. By careful construction of such terraces, a high percentage of the soil will be retained. The most useful and farsighted adoption of the Mangum terrace would be on the sloping dark upland soils which are ordinarily cropped in rotations including much corn. By maintaining the surface soil and by supplying as much organic matter as possible these soils will long remain productive, and gullying can be prevented indefinitely.

Terracing has been recognized as a necessity in all the Gulf States, and numerous sloping fields which were farmed prior to the Civil War are still in a high state of cultivation and will continue to be as long as the terraces are maintained. In that section of the country the cultivation of sloping land without terracing would be considered as the height of folly. The fact that the number of abandoned fields is gradually increasing in Doniphan County is sufficient evidence that something should be done to stop the disastrous effects of erosion. There are national associations for the preservation of wild game, fish, and flowers, but none for the preservation of the soil, our most fundamental and important of all resources.

SOILS AND THEIR INTERPRETATION

The characteristics of fully developed virgin soils are primarily the products of climatic forces and the natural vegetation. Moisture and temperature are the forces which are the most important and far-reaching in effect, as they directly influence the processes of leaching, oxidation, aeration, and accumulation of organic matter, as well as the extent of physical and chemical changes wrought on the organic and inorganic materials from which soils are developed. Certain general soil characteristics brought about by climate are common to the soil of a particular region; but the differences in soils within a small area, which may constitute the basis of classification, are the effect of such local modifying agencies as drainage, relief, severity of erosion, the chemical character of the rock or geologic material, and the character of the natural vegetation.

The soil-forming processes, controlled by climatic and vegetative conditions, have been of greater influence in determining the character of the soils in Doniphan County as a whole than has the composition of the parent material. The two most important soils of the county have the same parent material, loess, but they differ widely in color and productivity. The wide variation of topographic features and the consequent effect on drainage obviously influence soil character very greatly. The unusual permeability of most of the soils and the wide variation of surface relief, even within comparatively short distances, have been influential in producing the wide variation in the abundance of, and depth to, the underlying carbonates.

The smooth well-drained upland soils of Doniphan County have received the impress of their climatic and vegetative environment to a remarkable degree. They lie in the prairie region of the United States, where the climate has been favorable to a heavy growth of prairie grasses, and have developed a thick very dark-brown or black surface layer containing from 5 to 7 per cent of well-decayed organic matter which is intimately mixed with the mineral constituents of the soil. These soils have become stabilized and have attained their maximum development as governed by the prevailing environment. Therefore they may be considered as normal or at least the best-developed soils of the county. They cover slightly more than one-half the total area of the county.

The greater part of the dark-colored upland soils has been derived from a silty calcareous deposit known as loess. It gives to the soils of the county a silty texture and generally friable subsoils.

A detailed description of Marshall silt loam, the most important normal dark-colored upland soil, follows:

A thin veneer, from one-fourth to one-half inch thick, consisting of light-brown fluffy partly decomposed organic material, covers the surface soil which consists of a layer of very dark-brown (black when wet) floury silt loam 14 inches thick. This material has a single-grained finely granular structure, the granules ranging from one-sixteenth to one thirty-second inch in diameter. Very imperfectly developed laminæ, which are platelike or disklike in shape and overlap one another, occur in the upper 3 inches of this layer. Their presence, however is not recognizable in all profile examinations. Filled-in worm or insect borings about one-sixteenth inch in diameter extend in various directions, generally vertically. In general, the soil material in these borings is either lighter or darker than the rest of the soil within which the borings occur. This layer is rich in organic matter and is thickly matted with grass roots, especially in the upper 8 inches. The distribution and stage of decomposition of the organic constituents is not uniform, and the intensity of the dark color is slightly variable. The soil when cut or pulverized is only a very slightly lighter shade of dark brown, indicating that the organic matter is abundant and thoroughly disseminated with the mineral soil particles.

Below the topsoil is a 7-inch transitional layer which extends to a depth of 22 inches. The color grades from fairly dark brown in the upper part of the layer into light brown in the lower part, and the texture grades from heavy silt loam to silty clay loam. The structure is finely granular, the granules being more or less rounded and approximately from one-sixteenth to one thirty-second of an inch in thickness. The structure particles have a coating or film which is slightly darker brown than the inside of the particles. Worm and insect casts are less abundant than in the layer above.

The next lower layer, which extends to a depth of 30 inches, is the one of maximum compaction, though it is rather friable and permeable to downward or upward movement of moisture. This layer consists of grayish-brown silty clay loam of slightly lighter tint than the layer above. It is granular in structure, and when large aggregates are broken a decided vertical or columnar breakage is observed. Granulation is very indistinct in the lower part of this layer. The film or coating of the cleavage planes is very thin, as the faint coloring indicates. Small dark-brown threadlike lines are more conspicuous than in the layer above but are sparingly distributed.

The fourth layer is also transitional. It consists of grayish-yellow or yellowish-brown heavy silt loam representing parent loess. The basic color is yellowish brown with rather incipient splotching of grayish yellow. The material is a soft, friable, rather structureless mass which breaks easily, leaving rather sharp angular edges. The few cleavage faces which are noticeable are vertical. This material varies little to a depth ranging from 6 to 30 feet.

The lower substratum where exposed along old road cuts and banks has the peculiar ability to stand for a long time in a perpendicular bluff and breaks into columns. Only a few rust-brown stains are noticeable on the higher and more level situations, but at a depth ranging from 5 to 7 feet on the lower slopes the profile may contain

both lime concretions and irregular soft pipelike iron-oxide concretions. At a depth ranging from 3 to 5 feet calcium carbonate occurs rather sparingly, as indicated by effervescence with hydrochloric acid. Lime concretions are not abundant but where present generally range from one-fourth to one-half inch in diameter and are very irregular in outline.

The above-described layers vary considerably in depth and thickness. These variations are more pronounced because of the transitional character of all layers of the soil. The description is characteristic of the greater part of the upland soils which have gently undulating or mild topographic features. Among these soils may be included Marshall silty clay loam, gray-subsoil phase, of the upland, and Waukesha silt loam of the well-drained terraces. These soils are essentially alike in their characteristics. They are separated, however, because of differences in the mode of accumulation of the silty materials from which they have been formed. Marshall silty clay loam, gray-subsoil phase, has not been disturbed since its deposition, whereas the Waukesha soil consists of sediments derived from the uplands and deposited on the valley floors when the streams were flowing at higher levels. The soil material of Marshall silty clay loam, gray-subsoil phase, has weathered sufficiently to closely resemble the other soils of the Marshall series, however, and it may be regarded as transitional between the Marshall and Waukesha soils. The lower subsoil layers, although rather friable, are comparatively heavier than the corresponding layers of the other Marshall soils. The upper three layers are almost identical with those of the Marshall soils, but the fourth layer consists of light olive-gray heavy silty clay loam or silty clay, whereas this layer in the other Marshall soils is heavy silt loam having a more yellowish-gray color. The moderately heavy lower substratum in some places continues to a depth ranging from 6 to 8 or more feet, and in other places a slightly lighter-textured layer is present at a depth of about 5 feet. In both situations the gray color predominates, and a comparatively high percentage of rust-brown stains and rather soft accretions is present.

In a few small areas in the southwestern part of the county is a soil identified as Fillmore silty clay loam. It occurs in nearly flat areas and the relief has probably been responsible for the difference in soil characteristics between this soil and the Marshall soils.

The following is a description of the typical profile of this soil: The surface layer consists of very dark grayish-brown rather light silty clay loam 12 inches thick in which laminæ are present although imperfectly developed. The structure is finely granular, the granules being imperfectly rounded and few of them exceeding one-sixteenth inch in diameter. When the soil is pulverized the color is only slightly different, indicating a high organic-matter content. Numerous worm and insect casts are present, and the soil material within them is slightly lighter in color than the surrounding soil.

Below the surface layer is an intermediate layer which extends downward to a depth of about 18 inches. The texture grades from heavy silt loam to silty clay loam and in the lower inch of the layer to silty clay. The color grades from fairly dark grayish brown to slightly lighter brown in the lower part of the layer. On crushing, lighter shades of brown are noticeable, indicating that the film on the outside of the particles or structural units is darker in color. It is

apparent that the translocation of silt and organic matter by water percolating from above is not uniformly distributed about the smaller soil particles, due to the variability in the cohesiveness of the soil material. The contraction and expansion of soil material brought about by wetting and drying, freezing or thawing, or by roots cause natural irregular lines or cleavage planes of less cohesive strength; hence, in such places the film accumulates more abundantly and continues to do so because the film material is less cohesive. The structure of this layer is finely granular, and the granules are less rounded and appear to be more or less angular in the lower part of the layer.

A claypan layer about 8 inches thick constitutes the third layer of the profile and is the layer of maximum compaction. Here the soil material is stiff heavy clay which is very plastic when wet and breaks up into irregular aggregates of various shapes and sizes ranging from one-eighth to one-half inch in diameter. The structure may be said to be medium fragmental. The color of the aggregates is dull or dark brown on the outer face, but when the aggregates are broken, it is considerably lighter brown. The outside coating is shiny or glossy when wet, and the dark color decreases with depth. Immediately inside the outer film coating is a gray coating which seldom extends to the center of the particle. The inner part is either yellow, brown, or rust brown and is arranged in irregular-shaped thin layers or concentric rings, with the rust-brown coloration generally in the center, indicating a higher accumulation of iron compounds, hence a more cohesive tendency of the soil material under such influence. Small ferruginous pellets, most of which are about one-sixteenth inch in diameter, are scattered rather sparingly through this layer.

The next layer, which is about 16 inches thick, is lighter textured. It consists of light-gray or olive-gray rather plastic silty clay which is medium fragmental in structure. The outer coating of the structure particles is dull. The color of the whole soil mass in this layer is generally uniform, but a few darker streaks, or infiltrations, are noticeable in some places. Rust-brown stains and some splotching of yellowish brown are intermixed with the dominant gray soil material. Below the claypan layer is a friable light olive-gray silty clay loam layer about 20 inches thick, which extends to a depth of 70 or more inches. The soil material breaks into almost structureless clods with less distinct cleavage lines than in the layer above. A few rust-brown stains and small iron concretions are present.

Another soil, somewhat similar to Fillmore silty clay loam but having a heavier surface soil, is identified as Grundy silty clay loam. It occurs in the same part of the county as the Fillmore soil but in slightly more rolling areas. It differs from the Fillmore soil mainly in having less marked difference in texture between the surface soil and the subsoil. The subsoil is heavy but not heavy enough and hard enough to be called a definite claypan. In other respects this soil is essentially like Fillmore silty clay loam.

Variations in the color and depth of the surface horizons are noticeable throughout the soils of Doniphan County. On the more sloping situations the surface layer is not so thick because erosion has thinned this layer to greater or less extent. The soils of Doniphan County which have been largely influenced by pronounced topographic variations have been favorable to heavy forest vegetation.

Such vegetation does not produce a large accumulation of organic matter especially where erosion has assisted in thinning the surface covering. Therefore such soils are light in color and may be regarded as imperfectly developed.

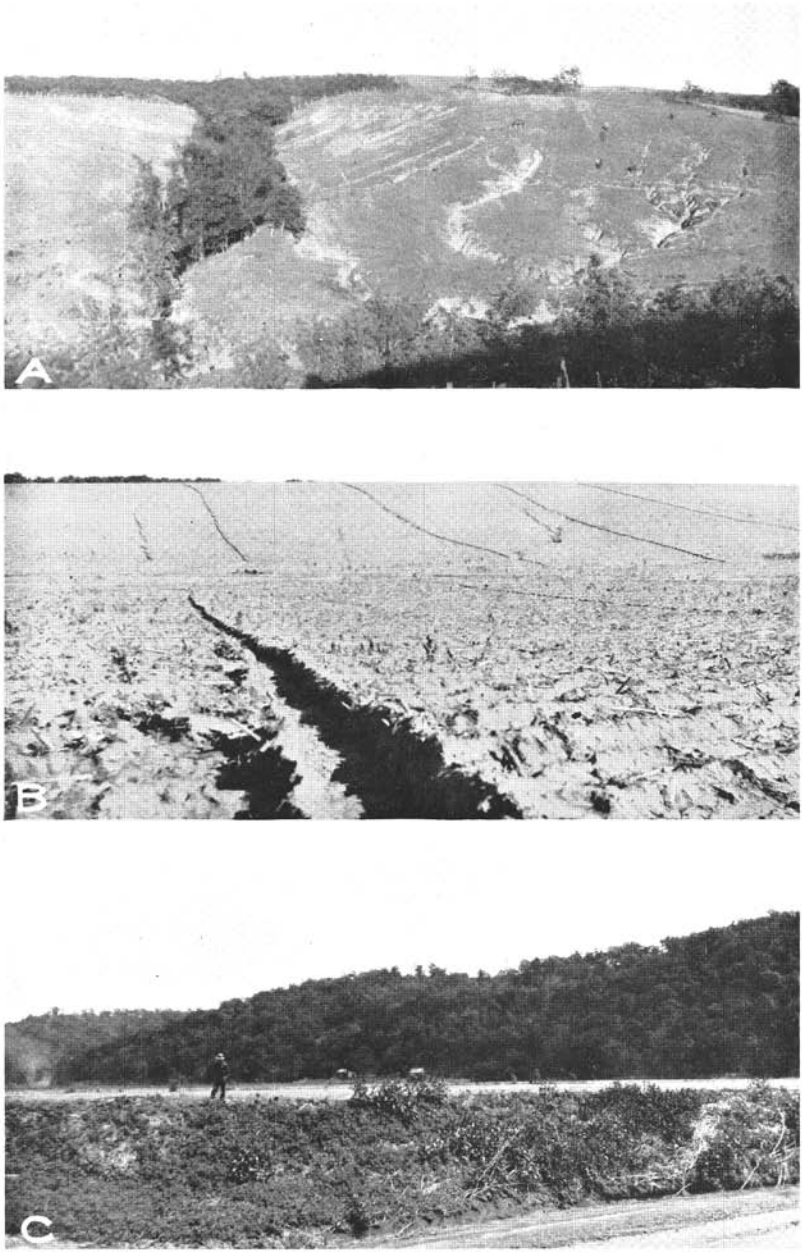
The following detailed description of the profile of Knox silt loam is typical of the most extensive of the imperfectly developed soils:

The surface is covered with a very thin mantle of decayed leaves and forest mold, below which is brown or grayish-brown floury silt loam 8 inches deep. This layer is underlain by a layer of lighter-brown or slightly yellowish-brown floury silt loam about 4 inches thick. In these layers individual soil grains have no definite arrangement, and the material is practically structureless. A slight sprinkling of light-gray soil particles is present. The next lower layer is about 8 inches thick and consists of yellowish-brown slightly heavier material which is rather cloddy or blocky when dry. The vertical cleavage lines impart a columnar appearance to the soil material which breaks down into a rather fine fragmental condition. The cleavage faces are slightly coated with grayish brown, and, on crushing, the soil material assumes a lighter-brown tint. This layer is underlain by a 10-inch layer which has similar texture (heavy silt loam or silty clay) but in the moist condition has a faint red tint. This layer and the one above are the layers of maximum compaction, but they are moderately friable. The structural particles are fine fragamental. Below this is the very friable heavy silt loam parent material extending downward to a depth ranging from 20 to 80 or more feet. Distinct splotching of rather light gray with yellow, brownish yellow, or buff appears in this layer.

Ordinarily the soil material at a depth of 40 or 50 inches effervesces freely with hydrochloric acid, but above that depth it is acid in reaction.

Knox silt loam is developed on the steeper slopes, which are, for the most part, covered with forest or brush, and it varies considerably in texture and in the depth at which calcium carbonate is present. The sharply rounded hills adjoining the Missouri River Valley ordinarily have a thinner surface layer, indicating a very small proportion of organic matter. The underlying layers have, in many places, only a slight development of heavier soil material and contain lime within a depth of 3 feet from the surface. The entire soil profile shows a comparatively higher proportion of very fine sand. Small thin shells of two species of land snails are very common in places, especially near Lookout Mountain in the northern part of the county. The land snails which inhabit such soil material are known as *Mesodon albolabris* and *Pyramidula alternata.*

In the southern part of the county are soils developed on rough areas where the loessial mantle is thin. These soils have been influenced more or less by the underlying residual limestone material and therefore have heavier subsoils. A typical profile of Newtonia silty clay loam, the most extensive of such soils, shows a surface layer of brown or grayish-brown floury silt loam, 8 inches thick, underlain by a 4-inch layer of light-brown silty clay loam of fine-granular structure. Below this is the layer of maximum compaction, which is 24 inches thick and consists of reddish-brown silty clay containing numerous small iron concretions or pellets and dark-brown stains. The lower part of the layer contains some grayish-brown as well as the dominant



A, Abandoned field on Knox silt loam, showing ditches formed from furrows made when land was in corn; B, ditches starting from open furrows on sloping listed cornfields; C, leveed field of Ray silt loam in the Missouri Valley built up from sediments from Knox uplands, and characteristic relief of Knox silt loam, steep phase, in background

reddish-brown color. The structure is granular or granular fragmental. The granules, which measure from about one-sixteenth to one thirty-second inch in diameter, are more rounded in the upper part of the layer than in the lower part. The film on the outside of the granules is decidedly darker than the material inside, as is indicated when the granules are crushed or cut, and the dark color diminishes in intensity toward the lower part of the layer. The next lower layer, which is 24 inches thick, consists of mottled gray and brown clay. The lower part of the layer is not quite so heavy as the upper part and it contains numerous dark-brown stains with specks of yellow and rust-brown concretionary material.

Closely associated with Newtonia silty clay loam, but occupying steeper slopes adjoining drainage ways, is its stony phase. In this soil the loessial mantle apparently is entirely removed, leaving the partly disintegrated residual limestone soil material exposed. Limestone ledges and fragmentary limestone are scattered over the surface, and the soil is underlain with either limestone rock or fragmentary limestone in varying abundance. In places, underlying shale is also present and may even be exposed at the surface, but it generally occurs directly below the heavier limestone ledges. No typical soil profile has developed. The surface layer contains a small quantity of organic matter.

The soils in the alluvial valleys which have been subjected to occasional overflow have been mapped as the Wabash, Ray, and Sarpy soils. These soils have not developed well-defined profiles and are considered very young, especially in their cycle of development. They are described in sufficient detail for practical or technical purposes in the chapter entitled "Soils and Crops."

SUMMARY

Doniphan County lies in the northeastern part of Kansas, with Missouri River bounding it on the north and east. It covers an area of 383 square miles. The county includes a rolling plateau, grass covered in the virgin condition, in which the broad trench of the Missouri River Valley has been cut to a depth of about 300 feet. The upland border of the Missouri River Valley is thoroughly dissected into a hilly belt. The rest of the county consists of the prairie plateau which has been somewhat modified by erosion.

The annual rainfall of the county is about 33 inches.

The agriculture of Doniphan County consists of general farming with corn as the dominant crop on the smooth prairie uplands and on the alluvial plains of Missouri River and other streams and of general farming in connection with truck and fruit farming on the hill lands where the soils are light in color.

The soils on the smooth prairie uplands are dark colored, almost black in places, and are silty in texture, having developed under grass cover from silty deposits identified by geologists as wind-blown loess. The most important soil is Marshall silt loam. This is a highly productive soil for corn, wheat, and other general farm crops. It is also a good soil for grass. Alfalfa, red clover, and other legumes are produced extensively.

Where erosion has removed the silty surface soil or a considerable part of it, the present surface soil consists of what was formerly the heavier-textured subsoil. Such areas are mapped as Marshall silty clay loam, and they are slightly more difficult to handle and are less productive than typical Marshall silt loam.

The dominant soils in the Missouri River Valley hill belt are light in color. These soils also are developed from loess, the same parent material as that from which the Marshall soils are developed. The smoothest areas are occupied by Knox silt loam, and the rougher areas, where erosion has removed the silty surface layer, by Newtonia silty clay loam and the heavy phase of Knox silt loam. Knox silt loam is extensively used for fruit growing and it is one of the leading apple-producing soils in the Middle West.

The alluvial soils vary greatly in color and texture but are all highly productive. The dominant dark-colored alluvial soils are members of the Wabash series, and the dominant light-colored alluvial soils are members of the Sarpy series. These soils are devoted chiefly to corn, wheat, and alfalfa.

[PUBLIC RESOLUTION No. 9]

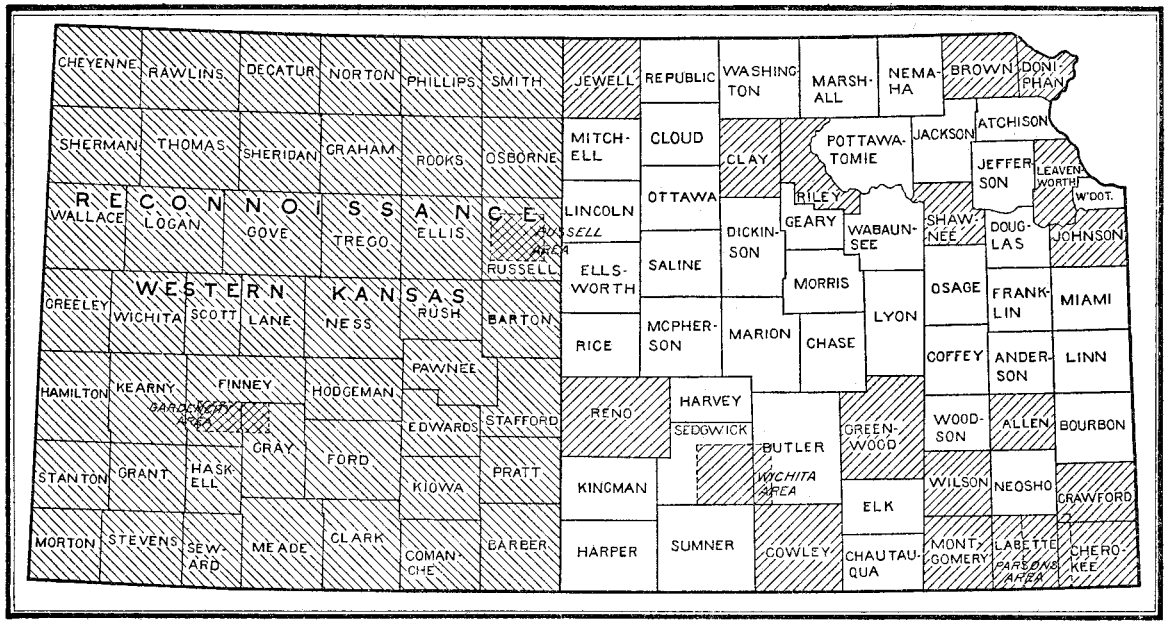
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

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

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

Approved, March 14, 1904.

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

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