Issued August 15, 1914.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

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

SOIL SURVEY OF JEWELL COUNTY, KANSAS.

BY

A. E. KOCHER, OF THE U. S. DEPARTMENT OF AGRICULTURE, AND J. P. STACK, E. H. SMIES, AND R. I. THROCKMORTON, OF THE KANSAS STATE AGRICULTURAL COLLEGE.

J. E. LAPHAM, INSPECTOR, NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1912.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1914.

BUREAU OF SOILS.

MILTON WHITNEY, *Chief of Bureau.*
ALBERT G. RICE, *Chief Clerk.*

SOIL SURVEY.

CURTIS F. MARBUT, *in Charge.*
G. W. BAUMANN, *Executive Assistant.*

COMMITTEE ON THE CORRELATION AND CLASSIFICATION OF SOILS.

CURTIS F. MARBUT, *Chairman.*
HUGH H. BENNETT, Inspector, Southern Division.
J. E. LAPHAM, Inspector, Northern Division.
MACY H. LAPHAM, Inspector, Western Division.
J. W. MCKERICHER, *Secretary.*

Issued August 15, 1914.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

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

SOIL SURVEY OF JEWELL COUNTY, KANSAS.

BY

A. E. KOCHER, OF THE U. S. DEPARTMENT OF AGRICULTURE, AND J. P. STACK, E. H. SMIES, AND R. I. THROCKMORTON, OF THE KANSAS STATE AGRICULTURAL COLLEGE.

J. E. LAPHAM, INSPECTOR, NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1912.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1914.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., November 29, 1913.

SIR: In continuance of the work in Kansas, which is being carried on in cooperation with the State, a survey of Jewell County was undertaken during the field season of 1912. The selection of this area was made after conference with the State officials.

The report and map covering this survey are transmitted herewith. I have the honor to recommend that these be published as advance sheets of the Field Operations of the Bureau of Soils, 1912, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

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

CONTENTS.

	Page.
SOIL SURVEY OF JEWELL COUNTY, KANSAS. BY A. E. KOCHER, OF THE U. S. DEPARTMENT OF AGRICULTURE, AND J. P. STACK, E. H. SMIES, AND R. I. THROCKMORTON, OF THE KANSAS STATE AGRICULTURAL COLLEGE	5
Description of the area	5
Climate	8
Agriculture	10
Soils	14
Colby silt loam	17
Colby silty clay loam	21
Colby very fine sandy loam	23
Jewell silt loam	24
Jewell silty clay	25
Belvidere silt loam	26
Benton silty clay loam	27
Benton stony loam	28
Rough broken land	31
Lincoln silt loam	31
Lincoln very fine sandy loam	35
Lincoln silty clay loam	36
Lincoln silty clay	37
Laurel fine sand	38
Laurel very fine sandy loam	39
Sarpy silt loam	40
Sarpy silty clay loam	40
Meadow	41
Salty marsh	42
Summary	42

ILLUSTRATIONS.

FIGURE.

	Page.
FIG. 1. Sketch map showing areas surveyed in Kansas	5

MAP.

Soil map, Jewell County sheet, Kansas.

SOIL SURVEY OF JEWELL COUNTY, KANSAS.

By A. E. KOCHER, of the U. S. Department of Agriculture, and J. P. STACK, E. H. SMIES, and R. I. THROCKMORTON, of the Kansas State Agricultural College.

DESCRIPTION OF THE AREA.

Jewell County is located on the north line of Kansas, midway between the east and west boundaries of the State. It is bounded on the north by Nebraska, on the east by Republic and Cloud Counties, on the south by Mitchell County, and on the west by Smith County. The county is 30 miles square and comprises 906 square miles, or 579,840 acres.

Jewell County lies between the Republican River on the north and east and the Solomon River on the south. Only the former enters

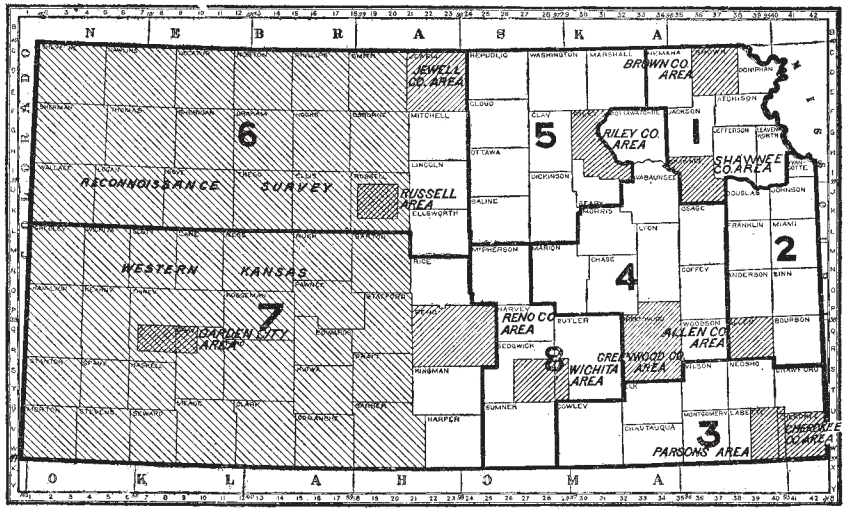

FIG. 1.—Sketch map showing areas surveyed in Kansas.

the county, yet the extensive valleys carved by these streams and their tributaries have had a marked influence on the topography of the county. The largest tributary is White Rock Creek, which passes in an easterly direction entirely across the north-central part of the county. The eastern and southern parts are drained by a number of streams, of which the largest are Buffalo, East and West Marsh, Limestone, West Limestone, and East Oak Creeks. In dry seasons these streams are all dry, and there are times when the Republican River carries the only running water in the county. In addition to

these streamways, the greater part of the county is cut by numerous dry draws which carry water after rains and furnish excellent systems of drainage. South of Ionia, Jewell, and Randall the country is flat, small streams are less numerous, and drainage is not so good.

Broadly speaking, the surface of the county presents three physiographic divisions, whose outlines, in a general way, mark the boundaries of the various soil groups; First, the high plateau and deeply eroded plains, which cover the northern and central parts of the county; second, the level or gently sloping plain, which lies 200 to 400 feet below the high plateau and bounds the latter division on the east and south; and, third, the numerous alluvial valleys.

The first division comprises about one-half of the entire area of the county and limits the coarser phase of the Colby silt loam. It ranges in elevation from 1,700 to 1,960 feet above sea. The highest altitude is attained about a mile south of the northwest corner of the county, from which point a gently sloping plain extends eastward for more than 20 miles. On the north this plain or high plateau is badly cut by the deeply eroded laterals of the Republican River, while on the south the country slopes rapidly to White Rock Creek. It ranges in width from a mere divide where the laterals of the two drainage systems interlace to a level table-land 2 or 3 miles across. About 2 miles south of White Rock Creek another level divide extends east and west near Esbon, Otego, and Mankato. On each side of this the country is considerably eroded.

Separating the high eroded plains from the lower, leveler plains is usually a rather steep escarpment. This line of hills, beginning well down toward the southwest corner of the county, passes in a general northeast direction near Ionia, Jewell, and Montrose, at which latter point it passes northwardly near Webber. Viewed from the hills, the lower plains have the appearance of a broad, level valley encircling the county on the east and south. The soils, however, are neither alluvial nor sedimentary, but are formed from the weathering of a deposit of fine loess. This topographic form, therefore, is almost entirely occupied by the Colby and Jewell soils. The third division—the alluvial valleys—is found along nearly every stream in the county. The largest occur along the Republican River, White Rock, Buffalo, East and West Marsh, Limestone, West Limestone, Brown, and East Oak Creeks, and range from one-fourth to 1 mile or more in width. In the eastern and southern parts of the county the surface slopes gradually to the valleys, but in the central part there is frequently a steep bluff of outcropping limestone separating the lowlands from the hills.

The first attempt to form a settlement in the county was made in 1862 near the now abandoned town of White Rock, and though several attempts were subsequently made to take up land in the

White Rock Valley the hostility of the Indian tribes prevented it until the summer of 1869. In 1870 many settlers arrived and took up claims on Buffalo and White Rock Creeks. In June of that year a fort was built on the present site of Jewell and the county was permanently organized, with Jewell as the county seat. Two years later the county seat was removed to Mankato, where it has remained. The first settlers came largely from Illinois, though nearly all of the near-by Eastern States were soon represented.

From 1870 to 1880 growth was rapid, the population increasing from 207 to 17,475. During the next decade the increase was less than 2,000. From 1890 to 1900 the total population of the county was practically unchanged, although there was a decided falling off in the rural districts. During the last decade, in spite of the growth of several small towns, the population decreased from 19,420 to 18,148. This loss has been sustained entirely by the rural districts, 18 of the 25 townships, exclusive of the towns therein, having a smaller population to-day than they had 20 years ago. The most thickly settled sections are the valleys and that part of the highlands adjacent to the railroads and towns. The people in the county are nearly all native Americans, whose industry and thrift are attested by their prosperity.

The chief towns, with their respective populations, as reported by the Federal census for 1910, are as follows: Mankato, the county seat, 1,555; Burr Oak, 1,132; Jewell, 839; Formoso, 453; Esbon, 347; and Randall, 325. Other towns of from 100 to 200 inhabitants are Ionia, Webber, Otego, Montrose, Lovewell, Dentonia, and North Branch.

With the exception of the northwestern part and the section around Ionia and Dentonia the county is well supplied with facilities for transportation. One of the main lines of the Chicago, Rock Island & Pacific Railway passes east and west through the central part of the county and gives direct communication with Denver, Kansas City, and Omaha. A line of the Missouri Pacific Railway, starting at Burr Oak in the productive valley of White Rock Creek, passes southeast across the county and joins the Central Branch of this system at Jamestown, a few miles east of the county. From this point the Central Branch extends southwest and west from 1 to 6 miles below the south county line. The Atchison, Topeka & Santa Fe, entering from the east, passes in a northerly direction across the eastern part of the county to Superior, Nebr. This point, which is only a mile north of the county line, is a shipping point of considerable importance, having, in addition to the Santa Fe, the Chicago & North Western, the Republican River branch of the Missouri Pacific, and the Burlington & Missouri River Railroad.

Being on direct lines to Omaha, Kansas City, and St. Joseph, the county has excellent facilities for the marketing of live stock. Much

of the corn grown is used in fattening cattle and hogs within the county, though the feeding of cattle is a much smaller industry than it was in former years. The wheat is sold at the local elevators and later shipped to the above-named markets, although some of it is made into flour at Jewell and Superior, a town just across the line in Nebraska. A small quantity of alfalfa hay is shipped from the county, but the greater part of it, as well as the oats and other feedstuffs, is fed to cattle or work stock at home. A number of small towns provide excellent local markets and consume all of the fruit and garden truck produced in the county.

CLIMATE.

The agriculture of an area is largely determined by the prevailing climatic conditions. The climate of Jewell County is that commonly found in inland regions of considerable elevation removed from the immediate effects of high mountain ranges or the tempering influence of large bodies of water. The air is usually dry and the temperature changes are frequent and sudden. The spring and fall months are marked by brisk wind movement, while the entire year is characterized by a high percentage of clear days. The summer temperatures are rather high, with occasional days of hot, dry winds, but the relatively low humidity of the atmosphere makes the heat much less oppressive than the same degree would be in the more humid Eastern States, while the nights are almost invariably cool.

The following data collected by the Weather Bureau at Concordia, in Cloud County, may be taken to represent the conditions in Jewell County:

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

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.
December	32	72	−10	0.5	T.	0.1	2.3
January	26	72	−25	0.7	0.5	0.3	5.3
'ebruary	28	79	−25	0.8	1.9	0.8	5.5
Winter	29	.....	.....	2.0	2.4	1.2	13.1
March	39	93	− 2	1.5	0.4	1.2	5.4
April	55	100	18	2.3	0.7	3.3	0.6
May	63	100	27	4.7	1.0	13.2	0.0
Spring	52	.....	.....	8.5	2.1	17.7	6.0

Normal monthly, seasonal, and annual temperature and precipitation at Concordia—Con.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	°F.	°F.	°F.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
June	73	104	43	4.3	3.9	4.0	0.0
July	78	106	46	3.7	1.0	5.2	0.0
August	76	104	41	2.9	5.0	4.3	0.0
Summer	76	.....	.....	10.9	9.9	13.5	0.0
September	68	104	29	2.4	0.9	1.8	0.0
October	56	93	20	2.2	0.7	2.9	0.1
November	41	82	−15	0.8	1.2	1.1	1.5
Fall	55	.....	.....	5.4	2.8	5.8	1.6
Year	53	106	−25	26.8	17.2	38.2	20.7

Average date of first killing frost in autumn, Oct. 14; of last in spring, Apr. 24. Date of earliest killing frost in autumn, Sept. 27; of latest in spring, May. 19.

An examination of the above table shows an annual precipitation of 26.8 inches. This is favorably distributed for the growth of crops, nearly three-fourths of it falling during the five months from April to August, inclusive, and nearly one-third during June and July. The table also shows a wide variation in the total amount of rainfall for the driest and wettest years, the former being 17.2 and the latter 38.2 inches. Because of the relatively high temperature and the dry condition of the atmosphere, due to the prevalence of hot, burning winds, evaporation is rapid and much care is necessary to prevent the loss of moisture during the crop-growing season. However, it is said that but four complete failures have occurred in the county during the past 41 years. These were in 1882, 1893, 1894, and 1901, when not even the seed was harvested. Droughts of less intensity have frequently occurred, but with the modern methods now in use there should be little danger of failing to secure profitable yields from most of the crops grown.

The average annual snowfall is 20.7 inches, but the snow rarely remains on the ground more than a few weeks at a time, and this lack of protection to winter grains causes more or less loss from the frequent freezing and thawing of the soil. Thunderstorms occur throughout the summer months and damage is occasionally done by lightning, wind, and hail.

The maximum range of temperature is 131°, the highest being 106° F. in July and the lowest −25° F. in January and February. Temperatures of 100° F. or more have been recorded for every month from April to September, inclusive, though such extremes are rare.

AGRICULTURE.

Agriculture began in the county in 1870, with the settlements at Jewell and on White Rock Creek. During the first few years only the bottom soils were farmed, the hills and upland prairies being used as a range for stock. Encouraged by the success in the valleys, the cultivated lands were gradually extended and it was not long before settlement pushed back to the uplands and the greater part of the county was in cultivated crops. In this county stock grazing as a dominant industry gave place to farming in a much shorter period after settlement than has usually been the case in this section of the State. The reason for this is undoubtedly the fact that the county possesses a large proportion of rich valley lands on which corn growing was highly successful from the start. As there were neither markets nor railroads to handle the crops, the feeding of cattle in connection with grazing soon became an important industry, and for a number of years the corn was marketed in this way.

In 1878 a branch of the Missouri Pacific Railway was built to Burr Oak and the establishment of communication with outside markets gave a decided impetus to agricultural development. Ten years later one of the main lines of the Chicago, Rock Island & Pacific Railway crossed the county and gave a direct route to Kansas City, Omaha, and St. Joseph. During this decade the acreage of corn was considerably more than doubled, the total production from one-fourth million acres in 1900 having been nearly 8½ million bushels, the largest recorded.

During the early years wheat was grown for home consumption, the spring and winter varieties occupying about an equal acreage. With the crude methods and implements then in use the yields were usually low, and since the spring seeding took time which could be spent more profitably in the corn fields the crop was never popular. With the later development of hard winter varieties which better withstand the severe winter climate, the growing of spring wheat was gradually discontinued and for nearly twenty years has had no place in the rotation.

Corn has always been the dominant crop, its total acreage for any year being far in excess of the combined acreage of all of the other crops. The average yield per acre in 1890 was 43.4 bushels, in 1900 it was 29 bushels, and in 1910 less than 17 bushels. While dry weather is undoubtedly the main cause of this apparent decline, the continual cropping to corn is also a contributing cause. Realizing this, the acreage has been gradually reduced and such crops as wheat, sorghum, and alfalfa have been given a larger place. Of the yellow varieties grown the most common are the Kansas Sunflower and Reids

Yellow Dent. Boone County White and Kellogg White Dent are also grown, the latter being especially popular in dry years and in the southern part of the county, on account of its drought-resisting qualities.

As a rule, the corn crop suffers more in the southern part of the county from the effects of hot southerly winds than it does in the northern part. The valley of White Rock Creek, extending east and west, is well protected from the winds, and the corn crop here is rarely affected by these winds. Several times since the county was settled the flooding of the Republican River Valley has covered the 2-mile bottoms from bank to bank. When such floods occur in summer the crops are entirely ruined, and this fact, combined with the presence of alkali in some of the lower areas, has caused the owners to devote a portion of the valley to pasturage.

For the first few years after settlement of the county wheat was grown extensively, the census for 1880 giving nearly 50,000 acres devoted to this crop. The yields in those days, however, were very low, the average for that year being only 6.9 bushels per acre Because of these discouraging results, which are directly traceable to the inferior seed used and the inadequate cultural methods, the acreage rapidly declined during the next decade. About 1890 the "Turkey Red" wheat was introduced from Russia, and this, together with several other varieties of Russian importation, had much to do with bringing wheat production back to a profitable basis. About this time, too, improved machinery began to be introduced and methods were adopted for the conservation of soil moisture.[1] During the last few years the Kansas Experiment Station has done valuable work in testing new varieties and in growing the most promising ones for distribution to the farmers throughout the State. The results obtained by using the improved seed are very gratifying, both the yield and the quality of the grain being superior to those of the common seed in nearly every case. Under the stimulus of this new movement the acreage of wheat is annually increasing. More wheat is grown in the southern part of the county than in the northern part, although each season the crop is being extended a little to the northward. According to the results obtained at the Experiment Station at Manhattan, Kans.,[2] the following varieties of hard red winter wheat seem best adapted to this section of the State: Kharkof, Malakoff, Defiance, Bearded Fife, and Ghirka.

Oats and rye have been grown to a limited extent, but the yields during the last few years have not been encouraging and the acreage has recently been reduced. Of the forage crops grown the most important are alfalfa, millet, Hungarian grasses, wild grasses, and the

[1] Bul. 176, Kansas Agr. Coll., How to Grow Wheat in Kansas, by W. M. Jardine and L. E. Call.
[2] Kansas Expt. Sta., Circular No. 3, Improved Seed Wheat, by A. M. Ten Eyck.

sorghums. The growing of alfalfa was begun about 1895 and the crop has now become second only to corn in importance. With the exception of the light-colored sands in the Republican River Valley, Salty marsh and the nonagricultural lands on the hills, the soils of the county are well adapted to this crop. It is especially remunerative on all the valley types of the Lincoln series. Its popularity is shown by the fact that in 1910 nearly 59,000 acres were devoted to it, while during the past two years this acreage has been considerably increased.

At present practically all of the county suited to cultivation is in cultivated crops. There are, therefore, no extensive areas of wild grasses left, the largest being in the stony or shaly sections, which are used chiefly for pastures.

The live-stock industry is an important branch of agriculture in the county, though the large herds on the range have been broken up and the number of cattle fed in the feed lots is much less than formerly. A number of high-grade horses and mules are raised each year and are either sold to buyers in the county or shipped to the markets at Kansas City, Omaha, or St. Joseph. Usually a few hogs are raised on each farm and there are some herds of considerable size. Considering the amount of excellent grazing to be had in the alfalfa fields and the availability of quantities of cheap corn, it would seem that this industry could be very profitably extended. There are a few sheep raised in the county, but owing to the fact that native grasses make poor winter grazing in this latitude, the industry has never been of much importance. During the past year a number of silos have been erected, which should be of especial value in laying the foundation for the further extension of the live-stock industry.

Apples are grown for home consumption and for the local markets. The trees are usually planted on the valley soils, where they make a more rapid growth than on the uplands, although the fruit is more liable to injury by frost.

Until the last few years very little attention has been given to the systematic rotation of crops. In many fields corn has occupied the ground for more than 30 years, while there are a few alfalfa fields that have not been broken for more than 16 years. The continuous growing of corn or any other cultivated crop without the addition of organic matter in some form is a wasteful method of farming, and if persisted in will eventually bring the soil into a condition where it will cease to produce profitably. Not only has continuous corn growing impaired the soil, but it has provided favorable conditions for the development of pests, of which the most destructive are the corn-root louse and the attendant brownish ants. The lice attack the roots of the young plant, causing it to turn yellow and die. The infestation seems to be most general in the rich valley soils and the destruction greatest in wet years. The pest spreads rapidly and in

badly infested fields is so destructive that it is sometimes necessary to plant three times before a stand can be secured.

In the past the adaptation of soils to crops has received but little attention, corn being grown on all of the agricultural soils of the county, but in recent years the marked adaptability of all of the Lincoln types to alfalfa has become quite generally recognized, and its introduction has caused a decided improvement in the agricultural conditions. The crop is also well adapted to the Colby soils, on which the acreage is annually increasing.

Wherever alfalfa is grown in connection with other crops the rotation is of necessity a long one. The crops commonly grown are corn, wheat, or oats, alfalfa and sorghum, or Kafir, in the order named. Both the corn and small-grain crops may be grown for two years in succession, while the alfalfa is usually left for three or four years. Sometimes cowpeas are planted in the first year's corn crop, to be grazed off in the fall, but this practice is not common.

The corn is usually listed between the 1st and 20th of May and harvested late in the fall either by the use of the corn harvester or by being husked from the standing stalk. Three or more cultivations are usually given, the first being with a double row disk cultivator, so arranged that the soil is thrown away from the row. The second cultivation is done with the same implement with the disks reversed, throwing the soil toward the row. After this operation the field has a level surface. Thereafter the disks are dispensed with, and the shovel cultivator, either single or 2-rowed, is used until the plants are too large to work. In these operations it is not unusual to use 4 or 5 animals to the implement.

The wheat is sown in September and harvesting begins about the first of July. Where the preceding crop has been wheat the preparation of the ground should be begun as soon as possible after the crop has been removed. From the results obtained by the Experiment Station at Manhattan, Kans.,[1] it was found that the most profitable method of preparing wheat land is to plow 7 inches deep not later than July 15 and conserve soil moisture by frequent shallow cultivations. Too much stress can not be placed on these results, as the net returns from the crop depend very much on the time and method of preparing the land.

Kafir, milo, and the other sorghums are either drilled or sown in rows. When drilled they are usually cut with the mower and treated as a hay crop, but when planted in rows they are cut and bound with the corn harvester. In most places the crops do best when planted in rows and cultivated, as by this means the soil moisture is more completely retained for the use of the crop.

[1] Bul. 176, Kansas Agr. Coll., How to Grow Wheat in Kansas, by W. M. Jardine and L. E. Call.

As a rule the manure on the farms is carefully conserved, though a few farmers still continue the wasteful practice of leaving it piled on the hillsides or on the banks of streams. Most of the straw is left stacked in the fields for several years, where it occupies valuable land, while a few farmers burn it in the stack after thrashing. Either practice is wasteful, as the straw has a high value when scattered over the wheat fields in winter. The county is well supplied with the most modern farm machinery, but very little care is given it after the season's work is done.

Most of the labor on the farm is done by the owner and his family. With the riding plows and other forms of improved machinery the labor problem is not nearly so serious as it was in former years, for now the children on the farm do with comparative ease what were formerly tiresome tasks for men. Hired help, however, is scarce. The corn is usually husked by the bushel, about 3 cents being the average price paid.

In general it may be said that for the last 40 years there has been a tendency to increase the size of individual farms. According to the census, the percentage of farms operated by owners in 1890 was 70.65, in 1900 it was 62.7, and in 1910 61.1. According to the same authority, the average size of farms for the last four decades was 163, 166, 169.5, and 183.6 acres, respectively.

When land is rented for cash the usual price is from $3 to $5 an acre. When worked on shares the owner, furnishing only the land and buildings, receives two-fifths of the crop.

Land values vary considerably in different parts of the county, though very little of it can be bought for less than $30 an acre. On the uplands most of it ranges from $45 to $75 an acre, while in the valleys it is held at $75 to $125 an acre. The total valuation of lands, improvements, and buildings in 1910, according to the census returns, was over $30,000,000.

SOILS.

Nineteen soil types and 5 phases were mapped in Jewell County. These fall naturally into four general groups: (1) Residual soils, or those derived from the underlying rocks; (2) loessial soils, or those formed from the weathering of wind-blown deposits; (3) soils of mixed loessial and residual origin; and (4) alluvial soils, or those laid down by the streams.

The oldest geological formation contributing to the soils of the county is of Cretaceous age [1] and is known as the Graneros shales—the basal member of the Benton group. The material consists of slate-colored shales that weather first into soft, thin flakes and then into

[1] Geology and Underground Water Resources of the Central Great Plains, by N. H. Darton, Professional Paper No. 32, U. S. Geol. Survey.

dark, heavy clay. The formation is exposed only on steep, eroded hillsides and has given rise to but one minor type, the Rough broken land.

Overlying the Graneros shales are several horizons of the Greenhorn limestone, of which the most important are the Lincoln marble, the Flagstone horizon, and the Fence-post horizon. The first of these consists of massive, bluish-gray limestone, with an average thickness of about 15 feet. The Flagstone horizon consists of several layers of hard-grained limestones, separated from one another by thin beds of shale, and having a total thickness in the county of about 10 feet. The Fence-post horizon is a capping of limestone about 9 inches thick, which has been extensively quarried and used for fence posts throughout this part of the State. Above the Greenhorn limestones lie the Carlile shales, the uppermost member of the Benton group. These consist of loose beds of light-colored shale and thin layers of limestone. Together these four formations occupy a considerable proportion of the central part of the county and in weathering have given rise to the Benton stony loam and a deep phase of this type.

Along the south slope of White Rock Creek and in a few places in the southern part of the county erosion has exposed the Niobrara formation, which consists of chalk, soft limestone, and shales. In the former location this has given rise to a dark-colored soil, which has been classified as the Benton silty clay loam, while in the southern part of the county its weathering in the presence of iron has given a type with a yellow subsoil, which has been classed as the Belvidere silt loam.

Overlying these formations and covering a large proportion of the county is a deposit of loess. It is composed of light yellowish brown silt and very fine sand, varying greatly in depth in different parts of the county. In the northwestern part, where the country consists of a high, level divide, its depth probably exceeds 100 feet, but in the central part, where the country is considerably eroded, much of it has been washed away, and on the slopes it has disappeared entirely. In weathering it has given rise to two important groups of soils, which have been correlated in the Colby and Jewell series. On the rolling prairies and high, level divides the soil is largely the Colby silt loam, but on the slopes most of the silt has been washed away, leaving exposed considerable areas of silty clay loam. The types of lightest textures are found in the northern part of the county, the bluffs along the Republican River valley being occupied by narrow strips of Colby silt loam, light phase, and Colby very fine sandy loam. South and east of the line of hills which passes across the southern and eastern parts of the county the loess material is of a finer grade, and from this has been formed a heavy phase of the Colby silt loam. In elevation it ranges from 1,500 to 1,600 feet above the sea, while the Colby silt

loam in the northern part of the county is found chiefly between the elevations of 1,700 and 1,900 feet. The heavy phase differs from the typical soil in having a finer, smoother feeling soil, a heavier and deeper subsoil, and a more uniformly level topography.

The origin of the Jewell silt loam, which occurs in small bodies throughout the southern part of the county, has not been definitely determined, but is thought to be due to an intermingling of the same loessial material that gives rise to the Colby soils with residual material from the underlying shales.

The alluvial soils may be grouped into three separate series, whose types are marked by distinct characteristics. The Lincoln series includes the dark-colored types not subject to overflow. They are found along every stream in the county except the Republican River, and constitute the most valuable soils in this section of the State. They are especially well developed in the valley of White Rock, Buffalo, East and West Marsh, Brown, Limestone, West Limestone, and East Oak Creeks. The types are composed of reworked loessial material, of which the greater part has been carried in from near-by upland prairies. Four types and two phases were mapped, ranging from very fine sandy loam to heavy clay.

The other two groups of alluvial soils are found in the bottoms of the Republican River and are each subject to overflow. The Sarpy series is characterized by dark-colored surface soils, containing considerable organic matter, and light-colored sandy subsoils, while the Laurel series is marked by light-colored sandy soils and subsoils. Two types of each series were mapped.

The following table gives the names and extent of the several types mapped in Jewell County:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Colby silt loam	185,088		Colby very fine sandy loam	5,056	0.8
Heavy phase	114,368	52.3	Lincoln very fine sandy loam	3,328	.6
Light phase	3,840		Jewell silty clay	2,688	.5
Colby silty clay loam	97,792	16.9	Laurel fine sand	2,240	.4
Lincoln silt loam	22,720		Laurel very fine sandy loam	2,176	.4
Colluvial phase	30,720	9.8	Belvidere silt loam	1,856	.3
Sandy subsoil phase	3,648		Lincoln silty clay	1,408	.2
Benton stony loam	31,168	9.2	Meadow	640	.1
Deep phase	21,952		Salty marsh	512	.1
Jewell silt loam	22,016	3.8	Sarpy silt loam	448	.1
Benton silty clay loam	9,408	1.6	Sarpy silty clay loam	384	.1
Lincoln silty clay loam	8,704	1.5			
Rough broken land	7,680	1.3	Total	579,840	

COLBY SILT LOAM.

The surface soil of the Colby silt loam consists of a brownish-gray to dark grayish brown silt loam containing a small amount of very fine sand and a high content of organic matter. The depth varies with the topography and the degree of weathering, ranging from 5 to 10 inches on the slopes and from 8 to 20 inches on the level areas. In the former locations the average depth is about 8 inches and in the latter about 14 inches. The silt in this soil is comparatively coarse and combined with the very fine sand gives the surface the texture of a coarse silt loam without that impalpable feel characteristically found in typical silt loams. As a rule the soil contains sufficient clay to give it a slightly compact structure when wet, and on drying a slight crust is not unusual on the surface.

The subsoil is usually made up of two distinct strata, the upper of which is a grayish-brown to reddish-brown, compact silty clay loam, becoming lighter in color and texture with increasing depth, while the lower is the pale yellowish gray, mealy, unaltered loess. The deep subsoil consists largely of silt and very fine sand, the sand content increasing toward the northwestern part of the county. In this part of the county the friable, unweathered loess has a slightly pinkish cast and is frequently found within 20 inches of the surface, while in the central part it is a little darker colored and is rarely found at depths less than 30 inches. White lime concretions from one-half to 3 or 4 inches in diameter are of frequent occurrence in the deep subsoil, and the surface material is usually well supplied with lime.

In a few instances small spots occur throughout the cultivated fields where the compact layer immediately below the soil has become so hard as to be locally known as "hardpan." When this material comes near the surface it makes cultivation very difficult, and in dry years almost impossible. The type as a whole is friable and easily worked and a fairly good tilth can be maintained with but little cultivation.

The Colby silt loam is the most extensively developed soil in the county. It constitutes the principal type on the high, rolling prairies in the central, western, and northern parts of the county, where it occurs as broad, level table-lands and fingerlike divides extending down between the numerous dry draws. The largest and most typically developed areas are found along the line of the Chicago, Rock Island & Pacific Railway in the vicinity of Mankato, Otego, and Esbon, and on the high table-land extending east and west through North Branch in the northwestern part of the county. In a general way its southern and eastern limits are coincident with the scarp

line which curves irregularly across the county near Ionia, Jewell, Montrose, and Webber. The type, however, grades gradually into the heavy phase of the Colby silt loam, which occupies the greater part of the lower plain in the southern part of the county.

The Colby silt loam is derived from the weathering of Tertiary loess. This material consists of loose deposits of light yellowish brown very fine sand and silt, which cover the high, level areas in the northwestern part of the county to a depth of 20 feet or more. Toward the south the loess thins out, forming a more and more shallow covering over the limestone and shales, until near the line of hills and in the eroded draws in the central part of the county the underlying rock formations are exposed. In the northern part of the county the material has weathered less deeply than in the central part, with the result that the unaltered loess is found nearer the surface in the former locality. The presence of the heavy substratum immediately above this material is probably due to the downward translocation of the finer silt and clay from the surface soil.

The type has a varied topography, ranging from broad, level areas in the higher parts of the county to gently sloping surfaces in the more eroded sections. The largest areas of level land are found along the line of the Chicago, Rock Island & Pacific Railway and on the high divide extending through North Branch. On either side of these divides the surface is badly cut by numerous draws, though very little of the type is so rough as to interfere seriously with cultivation.

The greater part of the type has sufficient relief to insure good surface drainage. After heavy rains water stands for a time on the level areas with impervious subsoils, but these are always small and can easily be improved by laying tile drains. Along some of the steeper slopes drainage is excessive and erosion is proceeding at a rapid rate.

With the exception of a few of these eroding strips along the draws, practically all of the Colby silt loam is under cultivation. Corn is the chief crop, the ordinary yields ranging from 18 to 25 bushels per acre. In favorable years well-tilled fields return a yield of 35 to 50 bushels per acre, though in dry seasons the yields are often low. Alfalfa is also an important crop on this type, occupying an acreage second only to that of corn. The crop is cut three or four times a year and yields from three-fourths ton to a ton per acre from each cutting, the average yield for the season being about 2½ tons per acre. During the last few years some wheat has been grown, but the yields are not often encouraging. As is the case with oats, very much depends on the season. In years of ample rainfall as much as 25 or 30 bushels per acre are obtained, but in dry years many of the fields are not worth harvesting. Millet, sorghum, and Kafir are the important forage crops of the type, and are among the surest crops produced.

In the past little attention has been given to rotation, some fields having been devoted almost exclusively to corn for more than 30 years. In favorable seasons such fields are still highly productive, but the practice has so greatly reduced the organic matter in the soil that in dry years the crops suffer badly from drought.

The Colby silt loam is one of the best upland soils in the county and ranges in price from $45 to $75 an acre, the greater part of it, away from the vicinity of towns, selling for about $50 an acre.

Colby silt loam, heavy phase.—The Colby silt loam, heavy phase, is closely associated with the Colby silt loam, the chief points of difference being that the former has a finer, smoother silt loam surface, a slightly heavier, deeper, and darker colored subsoil, a lower elevation, and a more uniformly level topography. It is probable, too, that in places the soils differ somewhat in origin, the heavy phase having been partially derived from the weathering of the underlying shales, while the typical soil has been derived entirely from loess. However, so intimately is the shale-formed soil mixed with the heavy phase of the Colby silt loam that it is not practicable to make a separation within the area where the heavy phase occurs.

The surface soil of the Colby silt loam, heavy phase, consists of 5 to 12 inches of dark grayish brown or medium-brown to dark-brown, smooth silt loam, which contains a small proportion of very fine sand, though there is always sufficient silt and clay to render the type slightly plastic when wet. When dry the color is grayer and the structure is loose and mellow. The subsoil consists of brownish-gray to grayish-brown or yellowish-brown, compact silty clay, which becomes lighter in both texture and color with increasing depth. At 30 to 40 inches this material grades into yellowish-gray to buff-colored friable silt loam carrying a few small concretions of lime. In those sections where the weathered products of the underlying shale have entered into the type the deep subsoil is somewhat heavier than that of the typical Colby soils. In the Reconnoissance Soil Survey of Western Kansas this condition covered extensive areas and the soil was designated as Summit silt loam, but in Jewell County the areas known to be chiefly residual are so small in extent or so greatly modified by the presence of loess that the type is considered as belonging more properly to the Colby series.

The Colby silt loam, heavy phase, is an extensive soil in the southern and eastern parts of the county. It occurs in many small bodies of very irregular outline and constitutes about one-half of the gently rolling country which lies below the general level of the hills. It is found well distributed over the southern tier of townships, near Jewell, Randall, Formoso, and in the country east of Webber.

The origin of this soil is largely due to the weathering of loess, which covers the greater part of the entire area of the county.

Toward the south and east the elevation becomes lower, the high plains terminating in an irregular line of hills. On the range of hills very little loess was deposited, or if deposited has been carried away by erosion. Over the lower plain, beyond the hills, the loessial deposits are again encountered, but being farther removed from the source of the material, they are much more shallow and of a finer grade.

The topography of this phase ranges from fairly level to gently undulating. In elevation it varies from 1,500 to 1,600 feet above the sea, while the main type is found chiefly between the elevations of 1,700 and 1,900 feet. Being of more level topography, the drainage is imperfectly developed, though the slope is generally sufficient to remove any excess of water.

The heavy phase of the Colby silt loam is one of the most popular soils in the county outside of the valleys of the streams. Its loose, mellow surface makes it easy to cultivate, and it is well adapted to all of the crops grown in the county. In the spring it is a little earlier soil than most of the types in the northern part of the county, but later in the season is more subject to the influence of hot southerly winds. The leading crops are corn, wheat, alfalfa, sorghum, Kafir, and oats.

Ordinarily the yield of corn ranges from 18 to 25 bushels per acre, but in favorable years from 30 to 50 bushels per acre are obtained.

During the last few years the growing of wheat on this phase has been considerably extended, until now it occupies an acreage probably second to that of corn. As a rule the results are somewhat more encouraging in the southern and eastern parts of the county than in the northern part, the yields in good seasons ranging from 25 to 30 bushels per acre.

Alfalfa is also an important crop on this soil, yielding 3 or 4 cuttings each season, with from three-fourths ton to a ton per acre per cutting. Kafir and sorghum are grown largely for fodder and are well adapted to the soil. When grown for grain Kafir yields from 25 to 40 bushels per acre.

The land of this phase is valued at $50 to $75 an acre, though in the vicinity of towns it is held as high as $100 an acre.

Colby silt loam, light phase.—The Colby silt loam, light phase, is an intermediate soil between the silt loam on the one hand and the very fine sandy loam on the other. Since it occurs only as a narrow strip between these soils, its texture varies considerably, the material merging into the silt loam type on the south and gradually giving place to the very fine sandy loam on the north. In general, however, it may be said to consist of about 12 inches of a brownish-gray loam, resting on a layer of light-gray or yellowish-gray, compact silty clay loam. At an average depth of about 24 inches there occurs a light

yellowish gray friable silt loam, which passes at 3 or 4 feet into a thick bed of light-gray fine sand. The type has a mellow, easily worked surface, and because of the heavy subsoil is fairly retentive of moisture. It is deficient in organic matter.

The light phase of the Colby silt loam is an inextensive soil found near the bluffs of the Republican River Valley in the northeastern corner of the county. The greater part of it has a moderately level to gently sloping topography, as it occupies the drainage divide between White Rock Creek and the Republican River. The drainage, therefore, is excellent.

Owing to its favorable topography, its ease of cultivation, and its relatively high average productiveness, this phase of the Colby silt loam is a popular soil, and practically its entire area is now under cultivation. Corn is the chief crop, the ordinary yields ranging from 18 to 25 bushels, with as much as 45 bushels per acre in favorable seasons. A small quantity of wheat is grown, the yield averaging about 20 bushels per acre. The soil is well adapted to alfalfa, although as yet only a small acreage of it is devoted to this crop. The yields range from 2½ to 4 tons per acre, depending on the season and the number of cuttings.

Land of this type of soil ranges in price from $60 to $100 an acre.

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

Mechanical analyses of Colby silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381110	Soil	0.0	0.1	0.1	0.5	10.2	71.8	17.0
381111	Subsoil	.0	.0	.1	.4	11.5	65.0	22.9
381112	Lower subsoil	.0	.1	.1	.2	8.2	71.2	20.2

COLBY SILTY CLAY LOAM.

The surface soil of the Colby silty clay loam consists of grayish-brown or brownish-gray silt loam or silty clay loam with an average depth of about 4 inches. In virgin areas or those left long undisturbed there is usually a covering of 3 to 5 inches of heavy silt loam, but under cultivation the plow brings the clayey subsoil to the surface and makes the type sticky and plastic. The subsoil, like that of the Colby silt loam, consists of two distinct strata. The upper one, extending to about 24 inches, is made up of grayish-brown to slightly reddish brown, compact silty clay loam, the lower one of lighter colored, unweathered loess. This deep subsoil material

usually consists of light yellowish gray, friable silt loam carrying a small amount of clay and very fine sand.

The type varies somewhat in different parts of the county, the difference being chiefly in the subsoil. In the northeastern part the compact layer is usually more shallow, permitting the unweathered loess to come within 15 or 20 inches of the surface, while in the southern part the heavy silty clay loam often extends to 3 feet or more without change. In the latter section and along some of the streams in other parts of the county the friable loess is entirely absent, the silty clay loam having weathered down to the underlying shale. While it is probable that in some of these sections the weathering of the shale has contributed somewhat to the soil, the areas so formed were of such small extent or were so slightly different from the main body of the type that it was not deemed practicable to separate them. In the northern part of the county the deep, friable subsoil contains a little more very fine sand than is found in other sections.

Although no large bodies of the Colby silty clay loam are found, the type is widely distributed and in the aggregate covers a considerable proportion of the county. It is most extensively developed in the hilly section east of Mankato, though it is found in smaller bodies along nearly every draw in the county. The largest bodies mapped are found near the east county line, in the vicinity of Lovewell and Montrose. Other important bodies are found about 4 miles west of Webber and about 3 miles west of Burr Oak.

The type owes its formation to the weathering of loess, but, since it occurs chiefly on the hillsides and slopes, erosion has carried away most of the silt loam covering, leaving the reddish-brown silty clay loam exposed. The type, therefore, represents the subsoil of the Colby silt loam which has been subjected to a greater degree of weathering. As is to be expected, the two soils merge very gradually into each other, the separation in many cases being based on whether or not a 5-inch plowing would bring the heavy subsoil to the surface. Along some of the lower slopes it is probable that the weathering of the underlying shales has contributed somewhat to the formation of this soil, but in no case were these areas of sufficient size to separate.

The topography of the greater part of the type ranges from gently sloping to quite steep. Usually the areas occur along the sides and around the heads of draws, but frequently they extend over the narrow divides and well up onto the high, level plateaus. Because of its sloping position, the soil is subject to considerable erosion and much care is necessary in cropping to prevent its further washing.

A large proportion of the Colby silty clay loam in the central part of the county has been broken up and placed in cultivation. In the

rougher sections much of it is still utilized for pastures. The type is not an easy one to work, and unless thoroughly cultivated is apt to suffer from drought. However, under thorough cultivation it has a high water-holding capacity, which makes it well adapted to the staple crops of the county. Corn occupies the largest acreage, the maximum yields ranging a little less than those usually secured from the Colby silt loam. Kafir and sorghum are grown quite extensively and, in addition to returning good yields, are popular crops because of their beneficial action in preventing erosion. For the same reason alfalfa has also come into favor on this type.

The Colby silty clay loam ranges in value from $35 to $50 an acre in the rougher sections, where it is used chiefly for grazing, and from $40 to $75 when under cultivation.

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

Mechanical analyses of Colby silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381107	Soil	0.0	0.1	0.2	1.5	9.6	59.5	29.3
381108	Subsoil	.0	.0	.2	.9	7.6	48.9	42.3
381109	Lower subsoil	.1	.1	.1	.9	9.0	67.8	21.9

COLBY VERY FINE SANDY LOAM.

The surface soil of the Colby very fine sandy loam, from 10 to 24 inches in depth, consists of grayish-brown to light brownish gray very fine sandy loam containing a relatively high percentage of silt. The subsoil to 36 inches consists of a yellowish-gray to buff-colored silt loam carrying a small amount of very fine sand. On the bluffs along the north side of the type the soil consists of brownish-gray very fine sandy loam, extending to a depth of 3 feet or more without material change, while around the heads of draws near the southern margin of the type the soil grades gradually into the Colby silt loam, light phase, from which it is very difficult of separation.

The type is rather inextensive, being found only in one continuous strip, about one-half to 1 mile in width, on the slopes leading down into the Republican River Valley, in the northeastern corner of the county. A few narrow strips of this body extend to the south along the deep erosions, but in no case is the type found more than 2 miles from the river bottoms.

The Colby very fine sandy loam is a loessial soil, formed largely by the weathering of fine materials which have been blown from the sandy soils in the Republican River Valley.

The surface is sloping to quite steep, though only on the sides of draws is it so rough as to preclude cultivation. Because of the steep topography, drainage is sometimes excessive.

About one-half of the type is used for cultivated crops and the rest has been left in native pastures. The principal crop is corn, which yields ordinarily from 15 to 25 bushels per acre. The open structure of the soil causes it to absorb rains readily, while the sand content causes it to warm up early in the spring. The soil is easy to cultivate and retains moisture throughout the growing season, making it well suited to crops which require early maturity. It is, however, deficient in humus.

The type is valued at $30 to $60 an acre, depending on location, improvements, and topography.

JEWELL SILT LOAM.

The surface soil of the Jewell silt loam consists of 10 to 12 inches of dark grayish brown to medium grayish brown smooth silt loam, carrying a relatively large amount of organic matter. Though there is sometimes enough clay present to make the soil slightly plastic when wet, it is usually friable and mellow and can be easily worked under a wide range of moisture conditions. The subsoil is made up of two or more strata. The upper one, extending from 12 to 20 inches, consists of dark grayish brown silty clay or silty clay loam. Below this lies a tough, compact layer of silty clay varying in color from gray to blackish brown. When wet this is very sticky and plastic and on drying becomes brittle and impervious, like hardpan. Lime concretions and reddish-brown iron stains mark this stratum and are sometimes seen throughout the lower depths. At a depth of 26 to 30 inches the compact layer grades into light-gray or mottled, friable silt loam or silty clay loam, having a structure not unlike that which underlies the Colby soils.

The Jewell silt loam is not an extensive type in Jewell County. It is found chiefly in the southeastern part, where it occupies the more level portions of the lower lying gently undulating plains. The largest bodies are found north and south of Randall, southeast of Webber, and about 1 mile south of Montrose. Other smaller bodies are found in the vicinity of Lovewell and Jewell and along the courses of many of the smaller streams in the southern part of the county.

The origin of the type has not been definitely determined, but it is thought to have been formed from an intermingling of loess deposits that give rise to the Colby soils with residual material from the underlying shales. It is possible that the heavy stratum in the subsoil may be in part due to the downward translocation of the finer particles in the soil. The gray and mottled coloring in the lower depths indicates a poor condition of aeration. Because of this compact stratum, un-

derdrainage has been retarded. This has favored a heavy growth of coarse prairie grass, and the accumulation of a large amount of organic matter in the soil.

The topography of the greater part of the type is level. This is especially true of the larger bodies which occupy the low divides between the small stream channels. The surface of the small bodies is usually gently sloping, as these are nearly always found along the courses of shallow draws. In all of the latter locations the type is well drained, but some of the level areas would be considerably benefited by tile drainage.

The Jewell silt loam is a productive soil and is well adapted to all of the crops now grown in the county. The soil is easily cultivated and in ordinary years is said to retain moisture a little better than the more elevated upland types. The results on this type nevertheless depend very much on the character of the rainfall. In favorable years excellent yields are secured, but, owing to the impervious hardpan below the surface, the deep subsoil is rarely wet except in the wettest years, and in these the surface soil is sometimes badly waterlogged.

The chief crops are corn, wheat, alfalfa, Kafir, and sorghum. In favorable years the corn yield ordinarily ranges between 30 and 35 bushels, with some fields yielding 45 or 50 bushels per acre. Since the land was first broken the average has been about 20 or 25 bushels per acre. During the last few years wheat has occupied a larger proportion of this type than of any other type in the county, the yield averaging for the last 6 crops about 20 bushels per acre. Alfalfa is an important crop on the type, yielding 3 to 4 tons of hay per acre for the season. Kafir, sorghum, and millet are grown extensively for forage on the sloping areas and yield well.

The Jewell silt loam has an average valuation of about $75 an acre.

The results of mechanical analyses of samples of the soil and subsoil of this type are given in the following table:

Mechanical analyses of Jewell silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381118	Soil	0.0	0.1	0.1	0.5	13.7	67.6	17.8
381119	Subsoil	.3	.4	.1	.3	9.3	67.4	22.0

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 381119, 1.84 per cent.

JEWELL SILTY CLAY.

The Jewell silty clay consists of 10 to 12 inches of dark-gray to grayish-brown silty clay, underlain by gray clay or silty clay. At an average depth of 24 inches the subsoil grades into light-gray or white

silty clay, containing a small amount of lime and slightly marked with reddish-brown iron stains. When wet the soil is sticky and plastic and in this condition it is very hard to work. In fact, unless it is worked when in the optimum moisture condition it is almost impossible to put it in good tilth.

The Jewell silty clay is an unimportant type. It is found only in a few small bodies on the sloping surfaces along the sides and around the heads of draws, in the southern and eastern parts of the county. Its origin is due to the weathering of loess, which has been mixed in places with the weathered products of near-by argillaceous shales.

The surface drainage of the type is good, but the heavy texture and compact structure of the subsoil retard the downward passage of water to such an extent that for some time after heavy rains the soil is too wet for cultivation. Because of this and the plastic and sticky nature of the soil, only a small proportion of it is used for cultivated crops, the greater part being still in native pasture. In many places the land is in need of open ditches or tile drains. Its physical condition could also be improved greatly by liberal applications of barnyard manure. In working this land care must be used not to plow it too wet, as the clods formed are hard to break down. With improved drainage conditions the land would be well adapted to alfalfa, corn, and the crops ordinarily grown in the county.

Land of this type of soil can be purchased for $35 to $45 an acre.

Mechanical analyses of samples of the soil and subsoil of the Jewell silty clay gave the following results:

Mechanical analyses of Jewell silty clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381120	Soil	0.1	0.3	0.2	0.8	9.0	47.8	41.8
381121	Subsoil	.1	.1	.1	.3	6.3	54.0	39.0

The following sample contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 381121, 0.93 per cent.

BELVIDERE SILT LOAM.

The Belvidere silt loam, although of small extent, has a rather wide range in texture. The surface soil ordinarily consists of 8 to 16 inches of grayish-brown to dark-brown, heavy silt loam, with an average depth of 12 inches. Small flakes of gray or yellowish shale are sometimes found throughout the soil, in places to such an extent as to give it the appearance of a shaly silt loam, but more frequently the soil is comparatively free from this material. The subsoil, to a depth of 36 inches, ranges from an ocherous-yellow, friable silt loam, closely approaching a silt, to a light-textured silty clay loam. Where the

friable silt predominates it usually extends several feet in depth, but where the subsoil consists of silty clay loam the material begins to pass into unweathered shale at 3 or 4 feet. Thin fragments of shale are also of common occurrence below the surface foot, and the entire soil profile is rather high in lime. The texture is always heaviest on the slopes. In such locations erosion has carried away the dark silty soil, leaving the yellow silty clay loam exposed. These exposures, surrounded by the darker soil, are usually very prominent, but being of too small extent to be shown separately on the map, they are included with the predominating phase.

The Belvidere silt loam is one of the less extensive soils in the county. It occurs only in the southern and eastern parts, the largest bodies, of which none are more than one-half section in extent, being found about 4 miles southwest of Ionia. A few small bodies are found southeast of Ionia, south of Jewell, and in the vicinity of Formoso.

The soil is residual in origin, being formed from the weathering of gray to yellowish calcareous shale of Cretaceous age. In the vicinity where the type occurs this shale immediately overlies and is frequently mixed with the dark-colored Graneros shale, instead of being separated from it by the usual bands of massive limestone. As a result, along steep slopes and in the deep subsoil the material gradually passes into the heavy clay of the Rough broken land. The prominent yellow color is probably due to the oxidation of iron, the presence of which is indicated by the frequent occurrence of reddish stains throughout the deep subsoil.

The Belvidere silt loam lies on moderate slopes and has excellent drainage. Only a small part of this type is under cultivation, as the soil in the cultivated fields is easily eroded. Where there is no shale in the surface material the soil holds moisture fairly well and produces fair yields of corn. Alfalfa makes a rather indifferent growth, though it has been planted as yet only to a small extent. The type affords good pasturage, for which purpose it is chiefly used.

BENTON SILTY CLAY LOAM.

The Benton silty clay loam consists of 8 to 12 inches of brownish-gray to dark-brown silty clay loam, with a high organic-matter content, resting on light brownish gray silty clay loam. At an average depth of about 24 inches the material becomes lighter both in color and texture and at 36 inches there is usually found a light yellowish gray, friable silty clay loam containing numerous small particles of lime. Below this depth the material passes gradually into marl, chalk, or shale. Frequently on the upper slopes the fields are marked with light-gray spots where the white calcareous material is found only a few inches below the surface. In such locations the soil resembles the deep phase of the Benton stony loam, but differs

from it in its higher content of chalk. In all cases the soil is loose and easy to cultivate, while its high-organic matter content gives it a higher water-holding capacity than is usually found in types of such porous subsoil.

This type is of comparatively small extent, being found mostly on the slope along the south side of White Rock Creek. Its most extensive development is in the vicinity of Burr Oak. Topographically it occupies an intermediate position between the upland prairies and the valleys. On its lower margin, therefore, it grades imperceptibly into the Lincoln silt loam, while on the upper slopes it passes gradually into the Colby soils. This favorable position is a valuable asset to the type, as it enables it to absorb a great deal of the water draining from the highlands to the valley.

The Benton silty clay loam is a residual soil, derived largely from the weathering of Niobrara chalk and the Benton shales. On the lower parts of the slopes the surface contains considerable colluvial material, and near its upper boundary more or less loessial material has been added to the soil. Under the influence of lime and a favorable moisture supply a great deal of organic matter has accumulated, to which is due the black color of the soil.

Nearly all of the type is under cultivation, the dominant crop being corn. Ordinarily yields of 25 to 30 bushels per acre are obtained, though in favorable years they are considerably greater. Where the soil is deep the type is well adapted to alfalfa, the yield ranging from 3 to 4 tons per acre. On the shallow areas this crop usually suffers from drought and not more than 2 or 3 tons to the acre is harvested. Some wheat and oats are grown, but the small grains do only moderately well. Kafir and sorghum are both important crops and return large yields of forage and grain. Land of this type is held at $60 to $100 an acre.

In the following table are given the results of mechanical analyses of samples of the soil and subsoil of the Benton silty clay loam:

Mechanical analyses of Benton silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381150	Soil	0.1	0.6	0.9	5.5	13.2	55.5	24.0
381151	Subsoil	.0	.3	.4	4.6	6.1	50.1	38.1

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 381150, 19.38 per cent; No. 381151, 40.13 per cent.

BENTON STONY LOAM.

The Benton stony loam represents the areas of rough, stony land adjoining the streams that have cut into the underlying shales and limestones. The surface soil, ranging in depth from 3 to 10 inches, con-

sists of dark-brown loam or silt loam carrying a high admixture of white calcareous shale and small fragments of partially disintegrated limestone. The subsoil, when any is present, consists of light brownish gray or yellowish-gray silty clay loam, which soon passes into limestone fragments varying from 2 or 3 inches to 8 inches in diameter. Frequently, however, the soil covering is very shallow and a stratum of limestone is found from 1 to 2 feet below the surface. On some of the steep slopes vertical walls of this material rise 20 to 50 feet in height and below these the surface is frequently strewn with large masses of limestone.

Areas of Benton stony loam are found along nearly all of the streams and draws in the eroded section of the south-central and eastern parts of the county. The type usually occurs as long, narrow strips occupying the upper part of steep slopes and extending back a short distance over the eroded uplands. Rarely are any of these areas more than one-fourth of a mile in width. The largest bodies are found skirting the uplands south of White Rock Creek in Sinclair and Richland Townships, in the vicinity of Montrose, and to the east and west of Ionia. Other bodies are found on the south slope of Buffalo Creek, in the vicinity of Randall, and along East Marsh Creek, southeast of Formoso.

The Benton stony loam is a residual soil derived from the weathering of Carlile shale and two or more horizons of the Greenhorn limestone. Usually the shale has contributed most largely to the soil, as the upper layer of limestone, known as the Fence-post formation, is very slow in weathering and has protected the massive underlying formation. These various formations together constitute what is known as the Benton group. Near the upper margins of the type it is probable that much of the surface soil has been derived from a thin covering of silty material blown in from adjoining areas of Colby silt loam.

Usually the topography is steep and precipitous along the larger streams, but away from the streams it becomes more gentle and joins the other upland types in gentle slopes. Much of the surface is badly dissected by deeply eroded draws, which occur with such frequency that in places the type is a succession of irregular divides separated from one another by stony, precipitous slopes.

The type is excessively drained and the character of the surface material is such that erosion is wearing it away rapidly and exposing additional areas of the underlying rock.

The Benton stony loam is too rough and stony to be of use for cultivated crops. With the exception of a few small areas where the rock outcrops, all of the type supports a good growth of native grasses. On some of the small benches these are mowed for hay, but the

greater part of the type is used solely for pasture, for which purpose it is best adapted.

Land of this type is valued at $20 to $30 an acre. The price is dependent largely on the presence or absence of water for stock.

Benton stony loam, deep phase.—The Benton stony loam, deep phase, is closely associated with the main type. The chief points of difference are that the phase has a deeper soil, with less limestone in the subsoil, and a somewhat more level topography. It is, therefore, a little better adapted to cultivated crops.

The surface soil consists of 6 to 12 inches of dark-brown silt loam or loam, having a high content of white, argillaceous shale. The subsoil is made up almost entirely of thin flakes of calcareous shale carrying a small amount of grayish-brown silt and clay, which grades at about 2 feet into a layer of disintegrating limestone. In places the outcropping shale constitutes the greater proportion of the entire soil mass and sometimes fragments of limestone are found scattered over the surface. The type is usually well supplied with organic matter and is always highly calcareous.

The Benton stony loam, deep phase, occurs in narrow strips along nearly all of the draws in the south-central part of the county. The largest bodies are found around the heads of draws and at the edge of the "breaks" between the Colby soils and the typical Benton stony loam. Many of the areas were of such small extent or so closely associated with the main type that no attempt was made to separate them on the map. The largest areas mapped are found in the section of rough topography south of White Rock Creek, to the north and northeast of Mankato.

The soil is derived largely from the weathering of Carlile shale, the uppermost member of the Benton group. In some cases the weathering of the underlying limestone has contributed to its formation, and where it joins the Colby soils the surface has been influenced considerably by loessial deposits.

The topography ranges from gently sloping to steep, as the phase occurs in sections which are profusely cut by draws. As the draw descends it cuts deeply into the underlying limestone, with the result that the deep phase soon gives place to the main type, or becomes so intimately mixed with it that a separation is impossible. As a rule, however, the deep phase is less broken than the typical soil, and a few areas are found whose topography is sufficiently level to permit of cultivation.

The soil supports a good growth of prairie grass, of which a few areas are cut for hay. A small acreage of sorghum and Kafir is cultivated, but neither the topography nor the character of the soil is favorable to the retention of moisture, and the result is discouraging, except in unusually wet years.

Though the land is priced at $20 to $30 an acre, it undoubtedly has a slightly higher value than that of the Benton stony loam.

ROUGH BROKEN LAND.

Rough broken land, occurring as it does on the sides of steep slopes where erosion is active in removing the material, is naturally a type of considerable variation. Typically it consists of steel-gray to bluish-black, heavy, plastic clay, resting on mottled black and yellow heavy clay of sticky, compact structure. At varying depths, depending on the state of weathering and the rapidity of erosion, the clay grades into thick beds of bluish-black or slate-colored shale. Sometimes the shale is found outcropping on the surface, but more frequently the soil is 8 to 12 inches deep, and the partially weathered shale is not encountered in the surface foot. Along the upper margin of the bluffs and wherever the type adjoins the light-colored shales of the Benton group the clay carries a high admixture of this material, but such areas are always of very limited extent. Gypsum is also present in some localities, and the water on the type is usually of very poor character.

Rough broken land is an unimportant soil, occurring only as narrow strips on steep, eroded hillsides. The most prominent areas occur about 4 miles west of Ionia, on the hills between Ionia and Jewell, and on the bluffs bordering the south side of White Rock Creek in Richland and Sinclair Townships. Other narrow strips are developed in the vicinity of Montrose and Lovewell.

Rough broken land is a residual soil derived from the weathering of slate-colored Graneros shale, the basal member of the Benton group. The shales are noncalcareous and on weathering break down at once into a heavy, plastic clay. Being of steep and broken topography, erosion prevents much accumulation of soil, while from the same cause many of the steep hillsides are almost bare of vegetation. However, where the hills are not too steep the type supports a good growth of native grasses.

None of the Rough broken land is under cultivation, as its rough and broken topography prevents it from being used for cultivated crops. For several years it has all been fenced and utilized in the pasturing of stock. Owing to the occurrence of the type in small and irregular bodies, it is never offered for sale except in connection with other soils. Its value, based entirely on its usefulness for pastures, ranges from $10 to $20 an acre.

LINCOLN SILT LOAM.

The surface soil of the Lincoln silt loam, to an average depth of about 12 inches, consists of dark-brown to brownish-gray silt loam with a high percentage of organic matter. The depth varies according

to the position which the type occupies, the soil being deepest in the wide bends of the rivers and at those points where the smaller streams enter the valleys. It is not infrequently 20 or more inches in depth, while in other parts of the valleys it is sometimes less than 8 inches deep. Throughout the greater part of the type the high content of organic matter renders the type friable and easily worked, though in a few cases where the soil is shallow it becomes rather hard and compact when dry.

The subsoil usually consists of two distinct strata, the upper one being a brown to dark-brown silty clay loam of compact structure, which grades at about 30 inches into light grayish brown or brownish-gray friable material of somewhat lighter texture.

The Lincoln silt loam is one of the most extensive valley soils in the county, being found along all of the larger streams, with the exception of the Republican River. It is most typically and extensively developed in the valley of White Rock Creek, where it extends, more or less broken by areas of other Lincoln types, entirely across the county. One of the most prominent and valuable bodies of the type is found in the immediate vicinity of Burr Oak, where 2,000 acres or more occur in one continuous body. Among the other areas of the type the most extensive are found in the valleys of Buffalo, East Marsh, Limestone, and West Limestone Creeks. Along these last-named streams a small amount of very fine sand is usually found below the surface foot, which gives the type a little lighter textured subsoil than is typical of the areas in the valley of White Rock Creek.

The Lincoln silt loam is derived from an old alluvial deposit. In places the deposit has a depth of 50 feet or more, the average in the White Rock Valley being about 30 feet. Into this thick stratum the streams later cut new channels, and they now flow 20 to 40 feet below the general level of the valley, a depth sufficient to prevent the flooding of the Lincoln soil.

The type has a nearly level, terracelike topography, with a slight fall in the direction of the streams. Usually the slope is sufficient to provide good drainage, though a few small depressed areas are in need of tiling.

This is one of the most productive soils in the county and is well adapted to all the crops grown in this part of the State. In addition to this it is an easy soil to cultivate. The largest acreage is devoted to corn, this crop having occupied some of the fields for 30 years without a change. Some of these fields have yielded 90 to 100 bushels of corn per acre for 3 years in succession, but for the last 3 years the average for the same fields has been but 30 bushels. In ordinary years the average for the type as a whole is about 30 bushels per acre, but in years of sufficient rainfall a yield of 50 to 70 bushels may reasonably be expected. During the last few years the acreage of

alfalfa has been greatly extended, as it has been found that this is one of the most profitable crops that can be grown on the type. Four cuttings, yielding three-fourths ton to a ton per acre, usually are harvested each year. Under the necessity of finding some crop to substitute for corn the acreage of wheat has recently been extended. Usually this is not a very profitable crop, though in favorable years from 20 to 30 bushels per acre are sometimes obtained. A small acreage of oats is grown for home use, but the crop is not often a commercial success. Kafir, sorghum, and millet do well on this soil, but owing to their drought-resisting nature they are planted more extensively on the uplands than in the valleys.

The Lincoln silt loam is one of the most desirable soils inthe county. Its value ranges from $65 to $100 an acre in sections remote from shipping facilities, and from $75 to $125 in the vicinity of towns.

Lincoln silt loam, colluvial phase.—The Lincoln silt loam, colluvial phase, is a medium to heavy silt loam with a high content of organic matter. When dry the color is a dark brownish gray to brown, but when wet it becomes dark brown. Because of the high organic-matter content, the soil is fairly friable and easily worked. At an average depth of 15 inches the soil grades into light brownish gray, friable silt loam containing a small amount of very fine sand. This usually gives place at depths varying from 20 to 30 inches to a thin stratum of brown to dark-brown compact silt loam containing considerable clay. Below this material the friable silt loam is again found, continuing to several feet in depth.

The Lincoln silt loam, colluvial phase, is a widely distributed soil, being found as narrow strips along nearly all the smaller streams in the county. The largest bodies, varying in width from one-fourth to one-half mile, occur along the upper courses of Limestone, West Limestone, Brown, Porcupine, East Oak, Buffalo, and East and West Marsh Creeks. Other bodies are found along nearly all the tributaries of these streams, as well as those which empty into White Rock Creek. The phase is very closely associated with the main type and in many cases the mapping of each includes small bodies of the other.

In formation this phase is largely colluvial, as it occurs chiefly along the streams of steep gradient, where the waters flow rapidly after heavy rains and carry to the lower levels most of the material cut from the hills. The materials which go to make up the soil are, therefore, chiefly those which have been washed down from adjacent slopes rather than those left by overflowing streams.

The topography ranges from fairly level in the larger bodies to gently inclined slopes along the narrow valleys. The drainage is usually excellent.

The position of this soil in relation to the upland types results in its receiving much of the water drained from these soils. This markedly improves its moisture conditions. The type is well adapted to all of the staple crops of the county, especially to alfalfa and corn. The latter is the chief crop, the yield being about the same as that secured in the wider valleys of Lincoln silt loam. Alfalfa is one of the most profitable crops that can be grown on this soil. Three or four cuttings a year are obtained, with a total yield of 3 to 4 tons of hay per season. It is also extensively used as summer pasturage for hogs, and where so used is usually cut but three times. In some of the narrow valleys kafir is grown for the grain, ordinarily yielding 25 to 45 bushels per acre. Sorghum and millet are grown for forage, and yield excellent returns. The soil is well adapted to the production of apples, berries, and small fruits, although these crops have been grown only for home consumption.

The Lincoln silt loam, colluvial phase, has a high economic importance, for though it occurs only in small bodies, its greater productiveness adds considerably to the general output of the county. Its value ranges from $75 to $125 an acre.

Lincoln silt loam, sandy subsoil phase.—The soil of the Lincoln silt loam, sandy subsoil phase, to an average depth of about 12 inches, consists of friable silt loam containing a small amount of very fine sand and a high content of organic matter. When the soil is dry the color ranges from dark gray to brownish gray, but when wet it is dark brown or black. The subsoil is a light brownish gray silt loam of slightly heavier texture than the soil, which grades at about 18 inches into light grayish brown silty very fine sandy loam. At from 30 to 36 inches the fine sandy subsoil becomes a little darker in color and of a slightly compact structure. Below this alternating layers of light and dark colored sandy material extend to depths of 30 to 50 feet.

This phase is limited in extent, being confined to comparatively small bodies within the valley of White Rock Creek.

The soil is alluvial in formation, having been deposited by swiftly flowing currents within the larger bends of the stream in times of overflow. With each successive overflow the valley was built up and with each increase in elevation the currents diminished, causing an ever increasing proportion of the finer materials to be carried in suspension. Thus, the surface soil is made up largely of silt, while the subsoil consists almost entirely of very fine sand.

The topography is nearly level, with a slight fall in the direction of the streams. The phase is quite safe from overflow, as the creek has cut its channel 20 to 40 feet below the surface. This condition, together with the open-structured subsoil, gives the soil excellent drainage.

The Lincoln silt loam, sandy subsoil phase, is a productive soil, easily worked and well adapted to a wide range of crops. For a number of years practically its entire area has been under cultivation, corn being practically the only crop grown. During the last few years, however, several fields have been seeded to alfalfa, and have yielded between 3 and 4 tons to the acre from as many cuttings annually. It is an excellent corn soil, yielding an average of about 30 bushels per acre, although in favorable years as much as 60 bushels is not unusual. Some wheat and oats have been grown in rotation with corn, but generally the results have not been encouraging. The soil is well adapted to sorghum, Kafir, and millet, though it is not used extensively for these crops. Apples and small fruits do well and are grown to a small extent. Because of the excellent underdrainage, the surface dries off quickly early in the spring and makes it possible to work these fields several days ahead of the heavier types. For this reason the soil should be well suited to vegetables and all such crops as depend for their success on early maturity. The land is valued at from $75 to $100 an acre.

LINCOLN VERY FINE SANDY LOAM.

Of the Lincoln soils encountered in the county the very fine sandy loam is the lightest, both in texture and color. The surface soil ranges from a medium to light brownish gray silty very fine sandy loam to brownish-gray very fine sandy loam containing a high content of rather coarse silt. At an average depth of about 12 inches the material grades into slightly lighter colored silty very fine sandy loam, which passes at about 30 inches into a thick stratum of light-gray coarse silt and very fine sand. The type is low in organic matter, but the presence of the fine sandy material gives a loose, mellow surface which permits of cultivation under a wide range of moisture conditions. In a few instances, notably about 3 miles southwest of Burr Oak, small spots are encountered in the fields where the surface soil rests upon a compact stratum of gray silty material at from 12 to 15 inches deep. During long periods of drought this material, apparently owing to the arrangement of the silt particles rather than to the presence of clay, dries and bakes into a condition resembling hardpan. On such spots crops suffer from drought and in dry years the yields are very low. However, they are always small in extent and of little importance.

The Lincoln very fine sandy loam is an inextensive type, occurring as narrow strips from one-eighth to one-fourth mile in width along the immediate bank of White Rock Creek. Such a strip, the longest in the county, extends from the west county line entirely across White Mound Township. Several other small bodies are found at

intervals along this stream in Burr Oak, Holmwood, Richland, and Sinclair Townships.

The type is an alluvial soil deposited by the swiftest currents of the stream in times of overflow. Farther from the channel the floodwaters flowed more slowly and were not swift enough to carry the coarser material, consequently the sandy soil was left along the immediate bank of the stream, while the finer materials were carried farther back.

The topography is level, but the character of the subsoil insures excellent drainage. Because of this, the type is the first in the valley to dry out in the spring and can, therefore, be worked several days earlier than adjoining heavier types.

This soil holds moisture well and is popular because of the ease with which it can be worked. It is productive and well adapted to the staple crops of the county. It is especially suited to the production of early truck, apples, and small fruits, though as yet only enough of these are grown for domestic use. The principal crop is corn, which yields ordinarily from 25 to 35 bushels per acre. Alfalfa gives 3 or 4 cuttings, the yield ranging from one-half to 1 ton per acre per cutting. Some wheat and oats are grown, but not always successfully.

Land of this type is valued at $75 to $80 an acre, though some of it has been sold for more than $100 an acre.

LINCOLN SILTY CLAY LOAM.

The Lincoln silty clay loam consists of 12 inches of dark brownish gray silty clay loam overlying material of about the same texture but of a lighter color. At 20 to 24 inches the subsoil grades into gray to light brownish gray silty clay loam, which becomes lighter textured with increasing depth. When wet the soil is sticky and plastic and in this condition is very difficult to work, but owing to the presence of a large quantity of organic matter it becomes friable and mellow under cultivation. If thoroughly worked it holds moisture well, but if allowed to become too dry the surface bakes and cracks and evaporation is rapid.

The type is found in small areas along nearly all of the larger streams in the county. The largest extend east from Randall, in the valley of Buffalo Creek, and in the vicinity of Rubens, in the valley of White Rock Creek. Other small but important areas are found in both of these valleys and along some of the other creeks. The Lincoln silty clay loam lies away from the streams and near the base of the hills and usually occupies a slightly depressed position with respect to the other Lincoln types.

The origin of the soil is alluvial, most of the material having been deposited by the backwater from the streams during overflows. In some cases the type occurs as an intermediate one between the

Lincoln silty clay and the lighter types of the series, and in such locations it represents a mixture of the coarser and finer materials of depositions.

The Lincoln silty clay loam is an excellent corn soil, yielding in exceptional years from 60 to 100 bushels per acre. In ordinary years this crop will yield from 35 to 50 bushels per acre. Because of the difficulty of preparing the land and the tendency of the soil to bake in the spring, it is often a hard matter to secure a good stand of corn, but after the stand is secured a crop is as certain on this type as on any other in the county. When properly drained, the soil is well adapted to alfalfa, and, considering the difficulty in working the land, it would seem that this crop could be extended with profit.

Small acreages of wheat, oats, Kafir, and sorghum are planted, good yields being usually obtained. Owing to the poorly drained condition of some of this type, only about three-fourths of it is under cultivation. The remaining area is used for pasture. Land of this type of soil is valued at $50 to $80 an acre.

LINCOLN SILTY CLAY.

The Lincoln silty clay is one of the heaviest soils in the county. It varies somewhat with its nearness to the heavy soils of the bluffs and its consequent method of formation. Immediately under the bluffs, where the soil is largely formed from the wash from the heavy clay of the Rough broken land, it consists of 8 to 10 inches of heavy, dark brownish gray clay, with a slightly bluish cast, grading into dark-gray, compact clay containing a few small particles of shale and lime. At an average depth of 24 inches the subsoil becomes a dark brownish gray compact silty clay loam with a rather high content of lime. Farther out in the valley, where the type is more largely of sedimentary origin, the soil is more uniformly dark gray to black and grades at a depth of 10 inches into heavy clay loam or silty clay of dark-gray color, which is sometimes mottled with brown. In these locations the lime and small particles of shale are usually entirely absent. When wet the soil is sticky and plastic and upon drying becomes baked and hard. Because of these tendencies, it is a difficult soil to work unless handled when in the proper condition with respect to moisture.

The Lincoln silty clay, although found in the valleys of the streams, is always closely associated with the heavy clay and dark-colored shales of the bluffs. It is most typically developed in the vicinity of Lovewell, where it occurs on the south side of the valley of White Rock Creek as an almost continuous strip one-fourth to one-half mile in width and several miles in length. Narrow strips are also found in the bottoms of Buffalo Creek. Occurring, as it does, along the base of the steeply eroded hills, it grades imperceptibly on its upper

slope into the heavy clay or partially weathered shale of the Rough broken land, while on the lower slopes it passes gradually into one of the lighter textured soils of the Lincoln series.

The type is both alluvial and colluvial in formation, that part nearest the streams being formed by repeated depositions in times of overflow, while that near the hills is mixed with material washed down from the adjoining bluffs.

Owing to its flat surface and its relatively low position with respect to the other Lincoln soils, which separate it from the streams, the drainage of the type is frequently deficient, and the construction of open ditches or the laying of tile drains would greatly enhance its value.

Only about one-half the type is in cultivation, the remainder being used as pasture. The chief crops are corn, alfalfa, and wheat. Corn yields from 25 to 45 bushels, alfalfa from 3 to 4 tons, and wheat from 10 to 15 bushels per acre. Land of this type is held at $60 to $100 an acre.

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

Mechanical analyses of Lincoln silty clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
381134	Soil	0.0	0.2	0.2	1.5	2.3	49.6	46.1
381135	Subsoil	.0	.0	.1	.6	1.9	40.7	56.5

LAUREL FINE SAND.

The surface soil of the Laurel fine sand consists of about 20 inches of gray fine sand of loose, open structure. The subsoil is a light-gray fine to medium sand, very loose and incoherent. In a few places, however, small lenses of black silty clay loam an inch or less in thickness are found between the soil and subsoil. The soil is made up chiefly of clean quartz sand and contains very little organic matter.

The Laurel fine sand is confined within the larger bends of the Republican River, where it has been deposited by the swifter currents in times of overflow. As it occurs next to the river, a part of it is still subject to overflow and is, therefore, being added to by each successive flood. Owing to its loose and incoherent structure, the soil is easily blown by the winds unless protected by vegetation, and much of the type has a billowy or dunelike topography, the ridges ranging from 10 to 20 feet in height.

Near the river the type supports a growth of cottonwood and farther back is partially covered with weeds and coarse grasses.

Owing to the tendency of the soil to drift, very little of it is cultivated. Corn yields from 10 to 20 bushels per acre. Attempts have been made to grow alfalfa on this soil, but it is not adapted to this crop. In its present condition the soil has very little agricultural value. The land ranges in price from $15 to $25 an acre.

LAUREL VERY FINE SANDY LOAM.

The surface soil of the Laurel very fine sandy loam consists of light-gray to brownish-gray very fine sandy loam, with an average depth of about 12 inches. Although the surface soil usually contains considerable silt, it is loose and friable of structure and easily cultivated. The subsoil to 24 inches consists of yellowish-gray fine sandy loam containing a small amount of silt and clay or light-gray fine to very fine sand. Below this depth it is nearly always light-gray, sharp, fine sand. At varying depths throughout the subsoil occurs a stratum of dark heavy silt or silty clay loam 1 to 2 inches in thickness. The color of this stratum is due to organic matter.

The type is of small extent, being found only in small bodies in the bottoms along the Republican River. These lie from 5 to 10 feet above the normal level of the stream. They are usually separated from the river by a low, narrow ridge of Laurel fine sand.

The surface is level and all of the type is subject to overflow. When not flooded the drainage in most cases is sufficient, though there are a few areas that would be greatly benefited by tiling.

The Laurel very fine sandy loam is alluvial in origin and is still being added to with each successive overflow. This is only a moderately productive soil. Its organic content is low, and unless carefully handled the type drifts easily. It is, however, capable of considerable improvement under intensive cultivation. Corn yields from 15 to 20 bushels per acre, with some of the better fields running as high as 30 bushels. Wheat is grown to a small extent and does fairly well. With its present low content of organic matter and lime the type is not well adapted to alfalfa. The soil warms up early in the spring and is well adapted to potatoes and all truck crops. In some of the poorly drained areas a small amount of salt is found in the soil, but the affected areas are of small extent.[1]

On account of the recent overflows, of which three have occurred within the last eight years, the type has a lower valuation to-day than

[1] The surface soil from one of the affected areas was analyzed by the chemical department of the Kansas State Agricultural College and gave the following results:

	Parts per million.
Total soluble matter	13,410
Nonvolatile soluble matter	12,030
Cl	709
Na_2SO_4	8,105
Na_2CO_3	1,640

it had formerly. Where uncultivated it supports chiefly spear grass and salt grass, which are used as pasturage. The land ranges in value from $35 to $50 an acre.

SARPY SILT LOAM.

The soil of the Sarpy silt loam consists of 12 to 14 inches of brownish-gray to brown silt loam containing a small quantity of fine sand and considerable organic matter. The subsoil over the larger part of the type consists of 14 to 36 inches of light brownish gray to yellowish-gray silty very fine sandy loam. In places the subsoil consists of 12 to 18 inches of black silty clay loam resting on clean gray sand which extends to a depth of several feet.

Only five small bodies of this type, with a combined area of less than a square mile, are found in Jewell County. These occur as narrow, shallow depressions which wind through the areas of lighter textured soils in the Republican River Valley. The subsoil has been formed by the deposition of coarse material during periods of flood when for a time the currents from the river flowed swiftly through these channels. As the flood plain became higher the currents flowed more slowly, depositing an increasing proportion of the finer materials.

With the Sarpy silty clay loam this type occupies the lowest position in the valley, and in times of overflow it is among the first soils to suffer. It has a level surface and being cut off from the river by the higher Laurel soils the drainage is poor.

When well drained this is an excellent corn soil, to which crop nearly its entire area is devoted. In favorable years the yield ranges from 35 to 60 bushels per acre, the average for a number of years being probably not far from 30 bushels. Land of this type of soil ranges in value from $45 to $75 an acre.

SARPY SILTY CLAY LOAM.

The Sarpy silty clay loam, associated as it is with long-abandoned channels of the Republican River, is a type of soil with very little uniformity in texture. In places it consists of 10 or 12 inches of brownish gray to brown silty clay loam containing a small amount of fine sand, and in other places it consists of 16 inches of dark brownish gray, heavy clay loam carrying a large amount of organic matter. The subsoil usually consists of light-gray fine sandy loam cut by one or more very thin layers of dark silty clay. In places a gray sharp sand of fine to medium texture begins at 24 inches, continuing downward for several feet.

The type is of little importance, as its total area in the county is only about a square mile. Three bodies were mapped, two of which occur within the bottoms of the Republican River and one in the bottom lying along White Rock Creek.

The Sarpy silty clay loam is an alluvial soil. In the Rebublican River Valley it occupies slightly depressed areas near the base of the hills and probably marks some of the former courses of the river.

The surface of the type is nearly level. The areas in the Republican River Valley, being slightly lower than some of the soils which separate them from the river, are rather poorly drained. The area near White Rock Creek occupies a slight elevation and is well drained.

The latter body is all under cultivation, being used for the production of corn. It is said that in dry years this soil retains moisture better than the lighter textured types, but in wet years the latter soils produce better corn. In the Republican River Valley only a small part of the type is under cultivation, the greater part being covered with a dense growth of elm, cottonwood, and willow or by a rank growth of weeds and native grasses. Where the land is cultivated corn has yielded as high as 90 bushels per acre and ordinarily in favorable years from 50 to 60 bushels per acre. If well drained and cultivated, this would be an excellent soil for all general crops now grown in the county. At present it is used chiefly for pasturage. The value of well-drained areas ranges from $75 to $100 an acre.

MEADOW.

Meadow comprises the low-lying areas along streams which are subject to frequent overflow and which have such varied textures as to make a strictly textural separation impracticable. The soils range from silty fine sandy loam to silty clay loam. Within the town of Burr Oak, where a small body of the type occurs, the soil contains a high percentage of very fine sand, but in most of the other areas the texture is a heavy silt loam. The color ranges from brown in the light-textured areas to black where the texture is heavy. The subsoil is even more variable than the soil, ranging from a fine sandy loam to clay.

Meadow is very inextensive in Jewell County, being found in only three areas along White Rock Creek. These occur at Burr Oak, near Rubens, and in section 12 of Holmwood Township.

The type is formed of materials deposited by successive overflows and represents parts of the present flood plain of this stream. It lies from 15 to 25 feet below the other valley soils and from 10 to 20 feet above the stream bed. Only the higher overflows, therefore, flood the type, although these are apt to occur during any month of the growing season.

The greater part of the type supports a dense growth of small trees, consisting of oak, ash, elm, cottonwood, and hackberry. The small area at Burr Oak is cultivated and when not overflowed yields from 60 to 90 bushels of corn per acre. The soil holds moisture

well and has been known to produce a crop without any rain after the time of planting.

The value of uncleared areas of this type ranges from $25 to $50 an acre, while the cultivated area at Burr Oak is held at $100 an acre.

SALTY MARSH.

As the term implies, Salty marsh differs from the land mapped as Meadow and from the other alluvial soils in that it carries injurious quantities of salt. The soil has little uniformity either in texture or color, the surface foot ranging from gray silt loam or fine sandy loam to a fine sandy clay or clay loam. Near the stream channel it is frequently a black, heavy clay, which when wet is very slippery and plastic. The subsoil varies from light-gray fine sandy loam to grayish-brown silty clay.

The type is found only along the streams in the eastern part of Vicksburg Township. Its area in Jewell County is small, being about 512 acres.

The soil is alluvial in formation, the presence of alkali being due to the dissolving of underlying beds of salt. This may also explain the depressed position which the type occupies with respect to the other soils of the valley.

Usually the surface is very level, resembling the bed of an ancient lake, though a few small areas are badly eroded, presenting a miniature "badland" topography. In the level spots drainage is poor, the stream splitting up into several shallow channels or wandering at will over the level flats.

Owing to the accumulation of salt, largely sodium chloride,[1] the type is unfit for cultivated crops. A part of the type supports a sparse growth of salt grass, which affords a little pasturage. The greater proportion of the land, however, is entirely bare of vegetation and in its present condition has little or no agricultural value.

SUMMARY.

Jewell County is located on the north line of Kansas, midway between the east and west boundaries of the State. It is 30 miles square and contains 906 square miles, or 579,840 acres.

There are three natural divisions in the county, viz, the high plateau and eroded plains in the northern and central parts; the lower, gently sloping plain in the southern part, and numerous alluvial valleys. Separating the first two divisions is a line of limestone hills.

[1] This soil was analyzed by the chemical department of the Kansas State Agricultural College and found to contain 13,365 parts of chlorine per million of soil of a moisture content of 15.31 per cent.

The county lies between the Republican River on the north and east and the Solomon River on the south and is well drained.

It was first settled in 1869 and the early development was rapid. During the last decade the population has fallen off, the loss being entirely in the rural districts. The people are nearly all native Americans.

The county has a number of small towns, of which the most important are Mankato, Burr Oak, Jewell, Formoso, and Randall. With the exception of the northwestern and southwestern parts, the county is well supplied with railroads. It is within reach of the Kansas City, Omaha, and St. Joseph markets.

The average annual rainfall is 26.8 inches, which is favorably distributed for the growth of crops. The mean annual temperature is 53° and there is an average growing season of 155 days.

Agriculture is well developed, practically all of the farming land being in cultivated crops. The principal crops are corn, alfalfa, wheat sorghum, Kafir, and millet. In the production of the first two crops the county ranks among the first in the State.

The live-stock industry is an important branch of agriculture, though fewer cattle are fed now than formerly. Many horses and mules are raised both for market and to supply the home demand. Some hogs are kept on nearly every farm. The extensive production of corn and alfalfa suggests the extension of the live-stock industry.

About 61 per cent of the farms are operated by the owners; the remainder mainly by tenants.

Land rents for $3 to $5 an acre, or for two-fifths of the crop.

In the uplands land values range from $45 to $75 and in the valleys from $75 to $125 an acre.

The farmers are prosperous and conditions are improving. The farms are equipped with modern labor-saving machinery.

Most of the farm labor is performed by the farmers and their families. Farm laborers receive from $35 to $40 a month.

Of the 19 soils mapped in the county, 3 are residual in origin, 3 are loessial, 2 mixed loessial and residual, 3 miscellaneous (Rough broken land, Meadow, and Salty marsh), and 8 alluvial. The residual soils are the Belvidere silt loam, Benton stony loam, with a deep phase, and the Benton silty clay loam. Of these the last is the only one of importance.

The loessial soils are of the Colby series; the two mixed loessial and residual are of the Jewell series. The Colby silt loam, with its light and heavy phases, occupies a large proportion of the county. The soils of these series are well adapted to corn, alfalfa, and the various forage crops.

There are three series of the alluvial soils, the Lincoln, Sarpy, and Laurel. The Lincoln soils, of which four were mapped, range in texture from very fine sandy loam to silty clay and constitute the most important soils in the county. The types are found along nearly all of the streams and are adapted to corn, alfalfa, and the general crops of the county. They are not subject to overflow.

The Sarpy silt loam and Sarpy silty clay loam, found along the Republican River, are characterized by dark surface soils and light-colored sandy subsoils.

The Laurel fine sand and very fine sandy loam are also found along the Republican River and consist of light-colored sandy soils and subsoils. The last four types are sometimes overflowed.

The narrow bodies of overflow land along White Rock Creek were mapped as Meadow, while a few salty areas in Vicksburg Township were mapped as Salty marsh. The latter has no agricultural value.

○

[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.]

NRCS Accessibility Statement

This document is not accessible by screen-reader software. The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at 1-800-457-3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at http://offices.sc.egov.usda.gov/locator/app.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.