

Issued July 17, 1914.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE UNIVERSITY OF MISSOURI AGRICULTURAL
EXPERIMENT STATION, F. B. MUMFORD, DIRECTOR.

SOIL SURVEY OF CARROLL COUNTY,
MISSOURI.

BY

E. S. VANATTA, OF THE U. S. DEPARTMENT OF AGRICULTURE,
AND L. V. DAVIS, OF THE UNIVERSITY OF MISSOURI.

J. E. LAPHAM, INSPECTOR IN CHARGE NORTHERN DIVISION.

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



WASHINGTON:
GOVERNMENT PRINTING OFFICE,
1914.

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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., November 8, 1913.

SIR: During the field season of 1912 a soil survey was made of Carroll County, Mo. This work was done in cooperation with the Missouri Agricultural Experiment Station, and the selection of the area was made after conference with State officials.

I have the honor to transmit herewith the manuscript report and map covering this work, and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1912, as authorized by law.

Very respectfully,

MILTON WHITNEY,
Chief of Bureau.

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

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MAP.

Soil map, Carroll County sheet, Missouri.

SOIL SURVEY OF CARROLL COUNTY, MISSOURI.

By E. S. VANATTA, of the U. S. Department of Agriculture, and L. V. DAVIS, of the University of Missouri.

DESCRIPTION OF THE AREA.

Carroll County, Mo., is situated in the northwestern part of the State, 211 miles northwest of St. Louis and 66 miles east of Kansas City. It is bounded on the north by Livingston County, on the west by Caldwell and Ray Counties, and is separated from Saline and Lafayette Counties on the south by the Missouri River and from

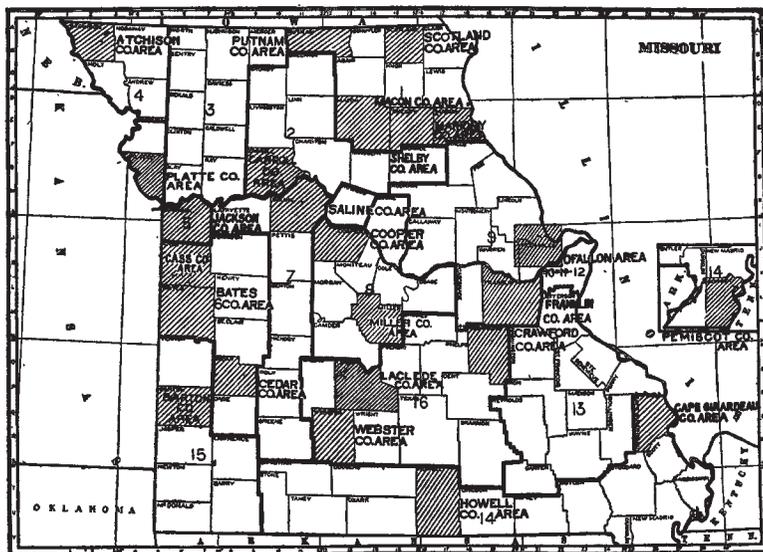


FIG. 1.—Sketch map showing areas surveyed in Missouri.

Chariton County on the east by the Grand River. It has an area of 703 square miles, or 449,920 acres.

The topography of the upland region of Carroll County varies from gently rolling to broken, the greater part being of a rolling nature. The general direction of flow of the large streams is to the southeast, and the valleys are separated by parallel ridges trending northwest and southeast. The streams usually have cut deep and precipitous banks. The gullies are gradually working back and ramifying in all directions, their rate of progress depending upon the resistance to erosion of the area they drain.

A strip of rolling to broken country extends from Livingston County down into Carroll County to a point a short distance south of Mandeville, from which point the series of ridges extends both to the northeast and northwest out of the county. The region is known locally as the Mandeville Hills.

A low belt entering the county about a mile east of the northwest corner, with a width of 1 to 3 miles, extends in a general southern to southeastern direction and separates the Mandeville Hills from the higher country in the northwestern part of the county and the adjacent part of Ray County. It merges into the upland plain south of the Mandeville Hills. In this county the belt is known as the "Low Gap." It has a generally undulating topography.

The bottom lands of the county, occupying so large an area and having generally a very fertile soil, are of much importance. There is a greater extent of Missouri River bottom lands in Carroll County than in any other county in the State of Missouri. At only one place in the county does the river approach within a quarter of a mile of the northern bluff, the distance from the bluff to the river throughout most of the county ranging from 4 to 9 miles. Very little of the bottom is subject to overflow by the river and practically all of it may be successfully drained. The topography is very gently undulating to flat, with many slight ridges and incomplete terraces following in general the course of the river. There is a faint ridge running east and west along the middle of the bottom-land belt. North of it the drainage is into Wakenda Creek, which flows along the bluffs, and south of it the drainage is directly into the river.

The main streams are the Missouri and Grand Rivers and their larger tributaries. The largest of these is Wakenda Creek, which, with its tributaries, drains the western part of the county and a large strip of the southern upland and northern bottoms as it flows eastward to the Missouri River. Big Creek and its tributaries drain most of the northeastern part of the county into Grand River. Very little water from the adjoining counties is carried through Carroll County and a very small run-off drains from this county into them. The alluvial belts along the creeks are comparatively broad and constitute a considerable part of the area.

The first known settler in the territory now embraced in Carroll County was Jonas Casen, of Cumberland County, Ky., who, with his family, settled during 1818 in what is now known as Sugartree Township. The early homes were situated along the Missouri River bottoms and foothills, convenient to shelter, water, and fuel. The fertile prairie lying back from the first bluffs was regarded as being of little value except for grazing.

In 1818 Government lands in the area were first advertised for sale. Again in 1820 lands which had not been previously sold or

which had been forfeited by default of payment were made subject to private entry at \$1.25 an acre.

The population of the county has been largely recruited from the surrounding districts, resulting in a general American community. There are no foreign colonies, such as exist in other parts of the State. The negro population is confined largely to the southern part of the county. According to the Thirteenth Census the population of Carroll County was 23,098, of which number about two-thirds live on the farms, while many of those living in the small towns and villages are more or less engaged in agriculture.

Carrollton, the county seat, was platted and organized in 1833 and is the largest town in the county, having a population of 3,452. It is noted for its wealth, and although it has several promising industries, is mainly an agricultural town. The town is exceptionally well equipped with paved streets, electricity, waterworks, etc. Norborne, in the southwestern part of the county, Hale, Bosworth, and Tina in the northeastern part, Bogard near the center, and Dewitt and Wakenda in the southeastern part, are important railroad towns. Several small inland towns are scattered over the county, especially in the northwestern part.

In late years there has been a marked increase in land values in Carroll County, as in other parts of the State. Illinois and Iowa farmers have moved in and invested mostly in the black bottom lands.

Before the development of the present railroad systems Carroll County was, for the period, well supplied with transportation facilities, being situated on the Missouri River and having many suitable landing places for boats. Several towns grew up by these landings, for which cargoes were hauled overland as far north as the State line. With the advent of the railroad and decline of river traffic only three of these, Dewitt, Miami Station, and Milespoint or Shanghai, remained, the latter consisting of only three or four houses. In recent years river traffic has been resumed to some extent and there is a chance that it may again become of importance.

With the exception of the northwestern part, Carroll County is well supplied with railroads. The Atchison, Topeka, & Santa Fe Railway from Chicago to Kansas City, entering the county northeast of Bosworth, extends in a southwesterly direction to Carrollton, where it enters the river bottoms, following them westward into Ray County. It has a double track and furnishes excellent transportation and shipping facilities. The Wabash Railroad from St. Louis to Kansas City, crossing the Grand River near Brunswick, follows the foot of the bluff in a general way across the county. From Carrollton Junction west to Camden the Wabash & Santa Fe combine for a double-track system. A branch line of the Chicago,

Burlington & Quincy Railroad extends in a northeasterly direction from Carrollton to Hale, where it leaves the county, running to Laclede, Mo., and connecting with the main line from St. Louis to Denver. The Chicago, Milwaukee & St. Paul Railway, from Kansas City to Chicago, passing through Braymer, a town just to the northwest of Carroll County, furnishes a shipping point for the northwestern section of the county.

The wagon roads of Carroll County have adhered closely to the land lines whenever possible. In some cases, especially in the rougher sections, it would seem that by following the topographic lines more desirable roads, as regards grade, could at times be had. With the increasing number of automobiles the good roads question is being agitated and a greater interest manifested in improving and repairing roads. There are no rock roads in the county. During the winter and spring months, especially in the heavier bottom lands, the roads are at times very nearly impassable. The rural free delivery of mail and telephone service reach all parts of the county and are made use of by the majority of the farming population.

CLIMATE.

The climate of Carroll County is essentially the same as that of Chariton County, and in the absence of local stations the data following have been taken from records of the Weather Bureau station at Brunswick, in the latter county. It is probable that these figures are more representative of the bottom lands than of the uplands, since Brunswick is located on the former. It is the general impression that a slightly greater rainfall is experienced in the bottoms and that changes in temperature are more sudden than in the uplands.

It will be observed from the following table that the average annual rainfall is 38.2 inches, sufficient to make the region humid. The total rainfall for the driest year is given as 19.6 inches, or slightly over half the normal, while during the wettest year 60.4 inches were recorded, nearly double the normal. Fortunately, these extremes are very rare, and in addition the soils of the greater part of the county can successfully withstand drought and the uplands, being well drained, are not as a rule seriously affected by a long rainy season. The greater part of the rainfall is evenly distributed over the late spring, summer, and early fall months, which constitute the growing season of this region. Droughts of over three weeks duration are rare. The average annual snowfall is 19 inches.

A considerable variation in temperature occurs during the year, though either extreme is usually of short duration. Wheat is sometimes winter killed, especially during very cold spells with no snow, but as a rule the snowfall is so distributed as to protect this crop from winter freezing. Peaches are very often injured by the ex-

treme cold of winter or by late spring frosts. The fall and early winter months are usually characterized by open, pleasant weather.

The average date of the first killing frost in autumn is October 20, and of the last in spring April 13. The date of the earliest killing frost in autumn is September 29, and of the latest in spring, May 1.

Normal monthly, seasonal, and annual temperature and precipitation at Brunswick, Mo.

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	<i>°F.</i>	<i>°F.</i>	<i>°F.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>
December.....	32	68	-22	1.7	1.9	0.8	2.9
January.....	28	70	-21	1.6	1.5	4.0	4.9
February.....	27	70	-27	1.9	1.3	2.0	8.6
Winter.....	29			5.2	4.7	6.8	16.4
March.....	40	84	- 1	2.4	3.7	5.9	1.3
April.....	55	97	15	3.0	2.0	3.1	0.8
May.....	64	92	31	5.0	1.2	11.9	0.0
Spring.....	53			10.4	6.9	20.9	2.1
June.....	73	99	37	5.6	1.4	9.9	0.0
July.....	77	103	50	4.5	1.8	3.1	0.0
August.....	75	99	47	4.1	1.2	5.2	0.0
Summer.....	75			14.2	4.4	18.2	0.0
September.....	68	95	32	3.8	2.0	5.3	0.0
October.....	57	93	18	2.9	1.2	6.6	0.1
November.....	41	77	3	2.0	0.4	2.6	0.4
Fall.....	55			8.7	3.6	14.5	0.5
Year.....	53	103	-27	38.2	19.6	60.4	19.0

AGRICULTURE.

Carroll County is an agricultural region and as such ranks high among the counties of the State. General farming, consisting of combined grain and stock farming, predominates as a whole over the county. In detail, however, the alluvial-land area of the southern part is largely a grain and truck section, while stock and grain farming constitute the agriculture of the upland. Although vast quantities of corn and wheat are produced, practically all the corn is fed to stock within the county.

The history of the agriculture of the county is similar to that of the surrounding river counties. The early pioneers followed the water courses, settling in a location convenient to shelter, wood, and water, subsisting largely upon food obtained from the water and woods while clearing and bringing their land into cultivation. The popula-

tion gradually increased and agriculture prospered up to the time of the Civil War. During the progress of the war times became hard and business was at a standstill. With the reestablishment of business on a firm basis agriculture has rapidly attained its present status.

In the early days tobacco, hemp, flax, and cotton were the main crops grown. With the exception of some tobacco, none of these crops are at present grown on a commercial scale.

At present practically all of the tillable land is under cultivation. The lower bottoms are being traversed with ditches and within a few years will be drained. A considerable area in the hills of the northwestern part and some areas along the bluffs, more especially in the southeastern part of the county, are at present covered with forest. Very little of the forest is of any commercial importance and should be displaced by a more valuable growth or cleared and, if too steep for cultivation, used as bluegrass pasture. There are very few areas too stony for such use.

Carroll County lies in what is known as the corn belt, although a large quantity of wheat as well as corn is grown. More wheat is grown in the southern half of the upland region and on the alluvial lands of the Missouri River than on the shallow soils with heavy subsoils in the northern part of the county.

In preparing the soil for wheat when it follows corn the land is usually disked both ways and well harrowed. In land previously in wheat, clover, or other stubble the field is usually plowed, then disked and harrowed well, as in the former case. The wheat is drilled usually at the rate of 5 pecks per acre and at a time varying from the middle of September to the middle of October. Many sow early, more willing to risk the Hessian fly than the chance of an early winter catching the wheat with a poorly established root system and therefore more likely to suffer damage from heaving during winter. Wheat is usually stacked by the small farmer, but is left standing in the shock until thrashing time by the large farmer, who either has his own thrashing outfit or can hire one at the most desirable time. It is said that a great deal of the grain is damaged annually in the hill region, as the thrashing outfits move to the bottom, where the crops are larger, as soon as the grain is ready, which is usually only a few days later than that in the upland, and do not return to finish thrashing in the upland until late in the season. Clover is often sown in the wheat in spring and turned under with the stubble in the fall. The price of wheat has been very good during the last few years and it has been a profitable crop.

Corn is grown throughout the county. The yield varies with the locality, but as a whole is excellent. The highest uniform yields are made in the bottoms, ranging, as a rule, from 60 to 90 bushels per acre. In the customary farm rotation corn follows clover. The sod

is turned under preferably in the fall, so that the organic matter will have more time to decay. In many instances the corn is listed, the belief being that when this is done it stands drought better, can be kept cleaner, and will have more support for the stalks, and thus stand better in the fall season. The greater part of the crop, however, is planted with the check-row planter. Under this plan, it would seem, the most uniform stand should be secured and the corn kept just as clean as listed corn. Also on rolling land during a wet spring and early summer it would not wash out of the row so badly. During the spring of 1912, after the hard rains, places were observed on the Knox silt loam where a small gully had appeared in each furrow, the young plants having been washed out or covered. In many cases this is the beginning of severe erosion. The greater part of the corn crop is either husked or snapped in the field, the stalks furnishing roughage for grazing cattle during the early winter. A good many silos have been built in the northern part of the county, and to fill these some green corn is cut. Some corn is also cut for fodder. Usually a sled cutter is used. Wheat is usually drilled in the stubble after the corn has been removed.

The most common varieties of corn grown are Reids Yellow Dent, Leaming, Boone County White, and St. Charles White. Boone County White, on account of its large stalk and heavy ear, is best adapted to the bottoms.

Oats are grown on a moderate acreage throughout the county and are mostly consumed by the work teams. This crop yields well and is a fairly good nurse crop for clover. Varieties having a tendency to withstand rust are generally grown, the plant being subject to this disease during the warm, damp growing weather.

There has been a gradual increase in the acreage of rye during the last few years. The crop is used to some extent for green manure or winter pasturage, but mainly for the grain. It is handled much the same as wheat and is claimed by some to be as profitable as wheat, especially in the uplands in the northern part of the county. Rye is successfully used as a food for all classes of live stock.

Sorghum is grown and manufactured into molasses in the numerous small local mills. Very little of the product is shipped out of the county. It produces good crops even on badly worn soil.

Kafir and milo are grown, though not extensively. They are cultivated very much the same as corn. In harvesting, the heads are usually broken off, dried, and stored. These grains are said to grow under very adverse conditions and to make excellent feed. Broom corn is grown to a limited extent.

Millet is grown extensively in the northern part of the county. It is used for green manure, for the seed, or, if cut when rather green, it makes a very good hay.

Red clover may be grown in practically every part of the county. It is usually sown in the spring with either wheat or oats and may be cut for hay or used for pasture in the fall. The following season two cuttings may be obtained, after which the sod is plowed under. The first cutting is ordinarily used for hay and the second for the seed. When sown with timothy an excellent hay is produced. Red clover is an excellent soil renovator, and, while the nitrogen stored in the roots is of value, more satisfactory fertilizing effects are obtained by turning the crop under as a green manure.

Alsike clover is grown successfully on the low, rather wet areas in which red clover does not thrive. For hay it is sown with timothy. It gives good yields and affords excellent fall pasturage.

Alfalfa makes a very good growth on the Knox silt loam, on the deeper Marshall silt loam lying next to the Knox, and on the lighter bottom land. This crop requires a rich, well-drained soil in good tilth. These requirements could not be better met than on the above-named soils, but the climatic conditions are unfavorable. The last two seasons having been unusually dry during the late spring and summer, alfalfa has been profitable. The crop is usually cut just as the new shoots are making their appearance at the crown of the plant. Three or four cuttings of about a ton each are usually made. After the first and second cuttings the field is usually cultivated. Double disking both ways has given good results. This serves to keep out the quack grass and other weed pests and does no harm to the deep-rooted alfalfa plant. Like clover, alfalfa is a valuable soil renovator.

Timothy is an important crop throughout the county. As a rule improved machinery is used in harvesting it. Much of it is cut with a binder and thrashed for the seed. The thrashed straw is good feed and is often baled or blown directly into the barn loft. Timothy seed usually yields \$6 to \$10 an acre. If used for hay alone, timothy and clover make an excellent combination. For the average year, under present conditions, timothy is perhaps the most profitable crop that may be grown on the Wabash clay or "gumbo." The main objection to hay grown on this heavy soil is its coarseness caused by rank growth, and this may be largely, if not entirely, overcome by heavy seeding.

Bluegrass is well suited to the entire upland and inland bottom regions, as well as to the greater part of the Missouri bottom lands of Carroll County. It is an excellent pasture grass and is often headed for the seed.

Cowpeas, a very valuable legume, are as yet little grown in this, a clover region. They are a valuable crop for any section, as in their short seasons they will gather nearly the same amount of nitrogen

that clover gathers during a much longer period. Cowpeas may be grown for hay, forage, seed, or green manuring. The hay, if properly cured, is very palatable to stock, as well as nutritious.

Cowpeas may be either broadcasted or drilled in the corn or planted alone. When planted alone a grain drill planting 4 to 5 pecks per acre should be used.

Some tobacco is grown locally in the county, but none on a commercial scale. Considerable tobacco is being grown in Chariton County, where the soil conditions are similar, but it is not proving profitable on account of the low prices received by the growers.

Live stock contributes substantially to the agricultural importance of Carroll County. Practically all of the stock raising and a large part of the feeding are carried on in the upland section of the county. During the year 1910 there were 17,567 head of cattle, 58,013 hogs, 2,530 horses and mules, and 7,523 head of sheep shipped out of the county.¹ The breeds of beef cattle preferred are Aberdeen Angus, Shorthorn, and Hereford. While the number of pure-bred cattle is not large, the majority of the animals are good grades.

The hogs of the county show evidence of being mostly well-graded Poland China or Duroc Jersey, with some Berkshire and Chester White. Occasional epidemics of hog cholera keep down the number. The hog-cholera serum has in a majority of the cases where used given practical immunity to the herd. The price of hogs has been very high the last year, and a great many are being raised at present.

There are no large individual flocks of sheep in the county, but nearly every farmer has a few. When managed in small flocks the percentage of profit from sheep is perhaps greater than from any other live stock on the farm. The principal breeds noted were Hampshire, Shropshire, and Southdown, mostly grades.

There are some very good pure-bred stallions in the county. Draft breeds, principally Percheron, predominate. There are also a number of good jacks. Good grade draft mares are plentiful, although there are very few pure-bred animals. The mules of the county are of excellent quality. Several teams that sold for \$600 were seen.

Dairying is carried on in a general way and as a side line, mostly in the north-central part of the county. Many silos have been built in recent years, and the number is being steadily added to. Although a profitable branch of farming, the labor and confinement involved have kept many from engaging in it.

In the production of poultry Carroll County ranks high. During 1910 there were 1,676,277 pounds of live poultry, 1,122,858 pounds of dressed poultry, 1,265,400 dozen eggs, and 41,922 pounds of feathers shipped from the county. Very little attention is paid to pure-

¹ Figures taken from Missouri Red Book, 1911, State board of labor statistics.

bred poultry on the farms. A large feeding and killing plant with a capacity for feeding 40,000 chickens is located in Carrollton.

The soils are well suited to fruit growing, especially along the loessial belt. Apples are the main fruit grown, large quantities being shipped to outside buyers. There are no exceptionally large orchards, but many of medium size. The Jonathan, Ben Davis, and Ralls (Genet) are the most popular varieties. Owing to the present disorganized system of handling and selling the fruit, a very low market price is obtained for it. Systematic spraying, if generally practiced, would greatly increase the quantity and quality of the fruit produced.

Small fruits and grapes are grown only for home use. Many small vineyards are scattered over the county.

Considerable trucking is done on the Knox silt loam and lighter bottom soils. Tomatoes are grown around Norborne in scattered areas, mostly along the bluffs and on the Sarpy soils near the river. They are canned in a factory at Norborne. Onions of good quality are grown on the lighter bottom soils east of Dewitt, giving large yields. A good many Irish potatoes are grown in the bottoms, more especially in the eastern half. Excellent watermelons and cantaloupes are grown on the sandy soils bordering the Missouri River.

With the exception of a large part of the area occupied by the Putnam and Marshall silt loams and the heavy part of the Missouri bottom lands, the county was at one time covered with a heavy tree growth. The front bottoms were occupied mostly by hard maple, cottonwood, pecan, hickory, and oak, the bottoms along the bluffs and inland streams by oak, hickory, walnut, and papaw, the loessial belt by elm, walnut, oak, and hickory, and the slopes and northwestern hill section mainly by oak and hickory. At the present time practically all of the tillable land has been cleared and is in cultivation. The heavier upland and bottom soils have always been known as prairie, the former having at one time supported a rank growth of prairie grass, while the bottoms supported prairie and swamp grass and various other kinds of water-loving vegetation.

The cultural methods generally practiced in the county are good. The desirability of a good seed bed is realized by most of the farmers. Fall plowing for corn is followed wherever practical. This has proved to be very injurious to the Knox silt loam, however, and should not be practiced unless a winter cover crop is to be sown. Some of the steeper slopes of this soil now under cultivation should be used for bluegrass pastures.

The practice of disking or otherwise cultivating the surface soil before turning it has generally been found beneficial.

Tile is used extensively, both for draining seepage areas in the upland and for general drainage over both upland and bottom regions.

Commercial fertilizers are being used to some extent, generally with wheat. A complete fertilizer is used by some on worn land. It is probable that phosphates applied in connection with barnyard manure and the turning under of an occasional crop of legumes, such as cowpeas or clover, would be sufficient for the majority of worn fields.

As a rule the stable and feed-lot manure is carefully saved. Manure spreaders are very generally owned throughout the county. The large quantity of manure resulting from the long-continued practice of stock feeding has been largely instrumental in holding much of the land up to its present state of fertility.

The practice of burning straw stacks, which is followed to some extent in the bottoms, is not to be commended. Although the bottom lands are at present strong and fertile, they should be carefully farmed, especially in sections that are practically never overflowed.

A good crop rotation, consisting of a combination of grain and legumes, is pretty generally followed throughout the county, especially in the uplands. The regular rotation is sometimes seriously interfered with by extremes of weather, such, for instance, as the killing of young clover by drought. Often cowpeas may be sown late in the summer following such clover failures with good results.

Improved farm machinery is extensively used in the county. The proper care and housing of machinery during the idle season is too often neglected, and thousands of dollars are annually lost in this way.

According to the Thirteenth Census, the average size of farms was 128 acres, an increase of 14 acres over the average of 1880. Of the 441,600 acres in the county, 376,946 acres, or over 85 per cent, is improved in farms. The total value of the land and improvements, except buildings, is estimated at \$24,977,133, something over \$50 per acre for the entire county.

Farms are, as a rule, rented on a share basis. In the better bottom lands the owner usually receives half the crops and a stipulated cash rent for buildings, lots, and pastures. In the thinner bottom lands and in the greater part of the uplands the terms are from one-third to two-fifths of the grain crop, one-half of the hay crop, and a stipulated cash rent for buildings, lots, and pastures. The census figures for 1880, 1890, 1900, and 1910 show a decrease in the number of farms operated by owners, the percentages being, respectively, 69.0, 72.4, 66.1, and 64.8. This decrease is largely due to the fact that many of the owners have moved to town and rented their land.

The labor problem is a serious one, especially on the average-sized farm. The gradual extension of the use of labor-saving machinery is tending to solve this problem to a certain extent. Monthly wages vary from \$20 to \$30 a month, with board and lodging. Day laborers are paid from \$1.50 to \$2.50 a day, depending upon the season and the demand for their services.

SOILS.

The soils of Carroll County are naturally grouped into upland and bottom-land types, according as they lie in one or the other of these two large physiographic divisions of the county. The soils of the two groups have again been divided into series and the series into types, the unit of soil mapping. The upland group is by far the most extensive.

The limestone, shale, and sandstone formations which underlie the upland region of the county were covered in early glacial times by a deposit known as the Kansas drift, which had a wide distribution and is supposed to have covered much of the northern part of the State. This drift, which varies from a few to many feet in thickness and is characterized by the presence of clay, sand, stones, and boulders, was subsequently covered by a layer of aeolian or loessial material, from which the greater proportion of the soils of the upland are derived.

In portions of the northwestern part of the county, where the underlying rocks were harder and the land maintains a greater elevation than the surrounding country, limestone ridges have been left. Here post-glacial erosion has been active, resulting in the entire removal of the loessial deposit and in places of the lower glacial till also, uncovering the older rocks.

The weathering of this limestone has resulted in the formation of the Mandeville silt loam—a residual soil. Occurring at the upper slopes and tops of some of these ridges an outcrop of bluish-gray fossiliferous limestone has given rise to a dark-brown stony soil, which has been classified as the Crawford silt loam. On the lower slopes of these ridges and again composing entire ridges a mixture of residual soil from sandstone, shale, and glacial material has been mapped as the Mandeville silt loam.

Over the lower hill slopes of most of the remaining upland the loessial deposit has been in whole or in part removed, exposing the underlying Glacial drift, from which the Shelby loam is principally derived.

The silty loessial material which wholly or in part overlies the glacial drift has given rise to the Putnam silt loam, rolling phase, and the Knox and Marshall silt loams, possessing different series characteristics based upon color and structure of the material.

The Putnam silt loam, rolling phase, occupies a wide belt of the higher, flatter uplands or drainage divides farthest north and most remote from the river. The dark color and silty texture of the type are in general like those of the Marshall silt loam, from which it differs principally in the possession of a heavier, more impervious subsoil. The Marshall silt loam occupies a relatively narrow and more or less discontinuous belt along the southern edge of the uplands between the Putnam silt loam, rolling phase, and the Knox silt loam. It has a relatively porous subsoil and the topography is more rolling than that of the Putnam silt loam, rolling phase.

The Knox silt loam represents the lighter colored loessial material, which has been mapped along the river bluffs over a belt of country varying in width from 1 to 4 miles. This material has its greatest depth along the river valley and gradually thins out to the north. The fact that it is not always underlain by the glacial drift, but often by the country rock, indicates that sufficient time for the partial erosion of the Kansas drift elapsed before the loess was deposited.

The alluvial deposits along the Missouri River and its tributaries in the county have given rise to several dark-colored soils, which have been included in the Wabash and Buckner series. They are represented by the Wabash clay, silty clay loam, and silt loam, and the Buckner loam and very fine sandy loam. Other lighter colored bottom-land soils, principally situated along the Missouri River and characterized by the possession of relatively lighter textured and more porous subsoils, have been classified in the Sarpy series as Sarpy clay, clay loam, and very fine sandy loam.

The material classified as Riverwash is principally confined to the Missouri River bottoms and has been thrown up nearest the channel by the constantly fluctuating currents of the river at each flood stage.

Two distinct soils have been mapped which, though classed in the River Flood Plains province, are not true alluvial soils. The Knox silt loam, colluvial phase, mapped along the base of the loessial bluffs and along one or two small draws extending a short distance back from the bluff, has been formed by an outwash from the Knox silt loam and is deposited over the true river bottom materials. Its topography is level and the soil is slightly lighter and coarser than its parent type. The Marshall silt loam, terrace phase, mapped in one area north of Dewitt, is to all appearances a loessial deposit over an old terrace made before the time of the aeolian drift deposit. Although very similar to the loessial soils, on account of its topography and occurrence, this soil has been mapped separately as a terrace soil.

The following table gives the names and extent of the various types mapped in the county:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Shelby loam.....	89,792	20.0	Sarpy clay.....	18,688	4.2
Putnam silt loam, rolling phase..	66,496	14.8	Sarpy very fine sandy loam.....	11,008	3.3
Marshall silt loam.....	56,000	12.5	Heavy subsoil phase.....	3,968	
Terrace phase.....	640		Buckner loam.....	14,720	3.3
Knox silt loam.....	45,376	11.0	Riverwash.....	7,040	1.6
Colluvial phase.....	4,096		Crawford silt loam.....	3,776	.8
Wabash clay.....	48,640	10.8	Buckner very fine sandy loam....	3,584	.8
Wabash silt loam, colluvial phase	29,376	6.5	Sarpy clay loam.....	1,088	.2
Mandeville silt loam.....	22,848	5.1			
Wabash silty clay loam.....	22,784	5.1	Total.....	449,920

KNOX SILT LOAM.

The surface soil of the Knox silt loam consists of a light-brown to brown, even-textured, yet comparatively coarse, silt loam, from 14 to 18 inches deep. The subsoil, from 16 to 36 inches, is composed of a light brown grading into a light yellowish brown silt loam, becoming a light friable silty clay to clay in the lower part of the profile. Along the bluff the loessial deposit is underlain by alternating layers of sandstone and shale, the glacial drift evidently having been removed by erosion before deposition of the loess. The color of the soil varies with the topography, the more broken areas near the river being of lighter color than the less rolling areas back from the bluff.

Back from the bluff line, where the loessial deposit becomes thinner, the heavy lower clay layers are sometimes found near the surface on the slopes. Seepage water encountering this relatively impervious material follows it to the point where it approaches the surface and forms wet areas known as "seeps."

The Knox silt loam is developed in a belt of land extending from the western to the eastern boundaries of the county, varying in width from one-half mile to 4 miles, lying just back from the river bottom and constituting what is known as the "river hills" or "red clay land."

The type owes its origin to the weathering of a deposit known as loess. The deposit is quite uniform in color and texture throughout its depth, contains no coarse fragmental rock or stones in its entire section, and is thought to have been windblown from the old valley of the adjacent river. It forms part of a more or less continuous belt along the courses of the Missouri and Mississippi Rivers, and has been mapped in various other areas throughout the State.

The depth of the deposit in Carroll County varies from 3 to 30 feet or more, and it is underlain by remnants of glacial drift. On its thinner northern edge, away from the bluff, where the stony and gravelly drift occurs in sufficient amount to alter the texture of the soil, the material has been mapped as Shelby loam.

The topography of the Knox silt loam varies from rolling to broken. The more broken areas occur east of Carrollton and extend to Dewitt.

Originally this soil was forested, but at present the greater part of the tillable land is cleared and in cultivation or pasture. Elm, walnut, hickory, and various oaks are the most common tree growth of this type.

Owing to its open structure and rolling topography, this soil is well drained, early to warm up in the spring, easily cultivated, and very much less unfavorably affected by drought than the types characterized by heavier subsoil lying north of it. Erosion, however, is often severe, owing to the loose structure of both soil and subsoil and its

usually sloping surface. Gullies formed are usually deep, with perpendicular walls exhibiting a checked and columnar structure peculiar to the loess. Cuts of this character 15 to 30 feet deep are common. As a safeguard against erosion the soil should never be left in a loose, uncovered condition during any period of rainy weather.

The Knox silt loam, with its deep friable subsoil and good drainage, is very well adapted to wheat production. From 18 to 25 bushels per acre is the usual yield. The berry is of good quality. Corn yields from 50 to 80 bushels per acre, but is not so extensively grown as wheat. Oats, while producing well, are not much grown. As bluegrass pasture land this soil has no superior in the county. Timothy and clover yield well and are largely grown both alone and mixed. When in a good state of cultivation the soil is excellently suited to alfalfa. Usually three cuttings are obtained.

Orchards, especially apple, are long lived and produce well and regularly on this type. More attention to pruning and spraying could be given profitably.

On account of its depth and early, warm nature, this soil is very well adapted to truck crops. Tomatoes, however, are the only one of this class of crops grown on a commercial scale at present. These are grown near Norborne.

Farms on the Knox silt loam are as a rule well improved and cared for. General farming, including the production of grain and the raising and feeding of live stock, is commonly followed.

Land values average about \$100 an acre for tillable tracts.

Knox silt loam, colluvial phase.—The Knox silt loam, colluvial phase, to a depth of 20 inches, consists of a light yellowish brown, rather coarse-textured silt loam. At this depth and below the texture becomes almost very fine sandy loam, and the color is grayish, the material passing at 28 to 30 inches into a dark-gray to black, compact silt loam, which in turn grades into a black, plastic clay, coming very rarely within the 3-foot soil section, except at the outer boundary line. As this belt of soil is simply an outwash from uplands, lying over the true bottom land, its depth is variable.

This phase of the Knox silt loam occurs in a narrow belt in the Missouri River bottom at the foot of the loessial bluffs. Its topography differs from other soils of this character in being nearly level, with only a very slight slope to the foot of the upland. Owing to the loose, open structure and elevation above the adjacent bottom lands, it is well drained and warms up early in the spring.

Excellent yields of corn, wheat, clover, and tomatoes are obtained on this soil. Owing to the narrowness of the belt in which it occurs, there are no farms situated on this phase alone, and it is rarely used for any other purpose than the production of grain and truck crops.

MARSHALL SILT LOAM.

The surface soil of the Marshall silt loam consists of a dark brownish gray or dark-brown to nearly black silt loam, from 14 to 20 inches in depth, resembling closely the surface soil of the Knox silt loam. The subsoil, extending from 20 to 36 inches, consists of a mottled drab and yellowish-brown silty clay, usually plastic, yet not so heavy as that of the Putnam silt loam, rolling phase. The color of the lower subsoil becomes lighter and the texture very frequently is more silty than the heavy middle section.

This type occupies a considerable portion of the upland region of Carroll County, forming a wide strip of country lying intermediate between the Knox silt loam and the Putnam silt loam, rolling phase. The topography is undulating to rolling, with generally just enough variation to insure excellent drainage without inducing erosion. The type as a whole constitutes a rolling, treeless plain, there being, in addition to a fringe of trees along the water courses, only a scattering growth of elm, walnut, and wild cherry trees.

Seepage areas are frequent in this type along the contact with the Knox silt loam, usually occurring midway on the slopes. These are formed where a lower lying heavy clay layer comes near the surface. These irregular areas, unless drained, are a serious drawback to cultivation of the fields containing them. During the spring months they are wet and cold long after the greater part of the land is in tillable condition.

The Marshall silt loam is derived from the loess by weathering under climatic and topographic conditions favorable to the accumulation of black organic matter. The subsoil of this type in Carroll County is heavier than is usually found in other areas, which may be due to a more thorough weathering or to the presence of till below a thin covering of loess.

In general, the Marshall silt loam is a fertile and highly productive soil. As is the case in any large soil area, small bodies or fields occur where, generally owing to erosion favored by a system of continuous cropping to grain, the soil is thin and unproductive. By a system of rotation involving the frequent growth of legumes and the plowing under of green manure these small areas may be greatly benefited.

Corn is probably the most extensively grown crop on this type. A yield of 45 to 75 bushels per acre is obtained during normal seasons. The soil stands drought very well, as shown by the growth made by corn during the drought of the present season (1912).

Wheat is a very widely grown crop and gives a yield of 18 to 30 bushels per acre of grain of good quality. The practice of spreading a prepared fertilizer with the wheat is carried on to some extent and is considered profitable. Oats yield well, but are grown for home use only.

The Marshall silt loam is an excellent soil for the production of bluegrass, timothy, and red clover. Lying as it does in a region

where considerable stock is raised and fed, a large part of the type is sowed to these grasses.

While as a rule the subsoil of this type is considered too heavy for the practical or profitable growing of alfalfa, several small fields of thrifty looking alfalfa were observed. From present knowledge of the crop and its requirements, however, the growing of alfalfa can not be recommended for this type as mapped in Carroll County.

Fruits produce well on the type, but are not much grown except for home use.

The houses, outbuildings, fences, and other improvements in this section are characteristically substantial and well kept. Water in sufficient quantity may be obtained at a depth of 50 to 80 feet, and most of the farms are supplied with wells and windmills.

Land of this type sells for \$80 to \$150 an acre, depending upon location and improvement.

Marshall silt loam, terrace phase.—The surface soil of the Marshall silt loam, terrace phase, consists of a dark-brown to black silt loam, from 14 to 18 inches in depth. The subsoil grades from a dark-brown to brown, compact silt loam to a depth of 30 inches, below which a light yellowish brown, friable, silty clay is encountered. Some small iron concretions occur in the lower depths.

The terrace phase of the Marshall silt loam occurs as a high bench of land, the main body of which is about 2 miles north of Dewitt. The slope from the Knox silt loam to the level of this bench is rather abrupt, with a drop of 50 to 100 feet, while from the Marshall silt loam to the west the slope is more gradual, yet very noticeable. From the level of this bench to that of the adjoining bottom there is a drop of 25 to 30 feet. The topography of this soil is gently undulating though maintaining the generally level character of a terrace formation. The soil is distinctly loessial in character and texture.

The Marshall silt loam, terrace phase, is of excellent quality, lies well, and is highly valued. Corn, wheat, alfalfa, clover, and bluegrass constitute the bulk of crops grown on it, high average yields being obtained.

The area of this soil is well improved and the buildings, fences, and other improvements are kept in good repair.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Marshall silt loam, terrace phase:

Mechanical analyses of Marshall silt loam, terrace phase.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
342633.....	Soil.....	0.0	0.2	0.4	0.6	1.9	77.5	19.7
342634.....	Subsoil.....	.1	.4	.3	.9	3.1	62.3	32.9

PUTNAM SILT LOAM, ROLLING PHASE.

The surface soil of the Putnam silt loam, rolling phase, consists of a brown to grayish-black, medium-textured silt loam from 8 to 12 inches deep, the color sometimes becoming grayish brown or gray at a depth of 12 to 16 inches. Frequently no change of color may be observed in the surface soil, especially along the more rolling areas. The subsoil as a rule consists of a very heavy, impervious, dark reddish brown clay, abruptly changing to a dull-brown, olive-brown, or sometimes mottled drab and brown heavy, plastic, though somewhat more friable, silty clay. At a depth of 28 to 30 inches the color often becomes yellow and brown, mottled with gray, and the soil is of a slightly lighter texture. The heavy subsoil, as well as the lighter lower section, is locally known as "hardpan."

This soil is of considerable extent in the northern section of Carroll County. The southern boundary of the type grades almost imperceptibly into the Marshall silt loam, and the boundary line is often arbitrary. Several small scattered areas have been mapped in the southern part of the upland region.

The Putnam silt loam, rolling phase, like the Marshall silt loam, is derived by weathering from the loessial material. It differs from the latter type principally in having a heavier and more impervious subsoil. This difference in the composition of the subsoil may be due either to a more thorough weathering or to the presence of material other than loess in the lower portion of the original formation from which it was derived.

The topography of the Putnam silt loam, rolling phase, in Carroll County is nowhere as level or flat as that mapped in the northeastern section of Missouri. The areas occurring in parts of the "Low Gap" region and around Hale vary from undulating to very gently rolling, while the remainder of the phase, with the exception of very small, nearly level areas, is gently rolling.

While very little of this type is too nearly level for good surface drainage, there is no doubt that the internal drainage is often very much restricted. Tiling the land would likely bring profitable returns over the greater part of the area. Under present conditions this soil does not stand either extreme of drought or rain as well as the types to the south of it having more friable subsoils.

Corn is the most profitable crop for this soil. The greater part of the crop is planted in thoroughly prepared seed beds, although some is listed. Yields vary from 30 to 60 bushels per acre, running somewhat lower than on either the Knox or the Marshall silt loams. Oats, largely of the rust-proof varieties, are grown extensively and usually yield well. Wheat does not produce so well here as on the deeper soils, although the crop is profitable and a large acreage is annually

sown. Commercial fertilizer is used for this crop. Timothy and red clover are grown extensively, both separately and mixed. Bluegrass thrives on this soil and there are many acres of it used for pasture.

The soil supports quite a stock raising and feeding industry, and is occupied by well-improved farms and fine country homes.

The price of land is variable. Very few of the better farms can be bought for less than \$75 to \$100 an acre, while often the price runs considerably higher.

SHELBY LOAM.

The surface soil of the Shelby loam varies from a silt loam to a loam, 8 to 12 inches deep and brown to dark brown in color, in many places containing numerous glacial pebbles. To a depth of 36 inches the subsoil consists of a reddish to yellowish-brown or mottled red and yellowish-brown heavy silty clay to clay, containing numerous glacial pebbles, fragments of sandstone, and lime and iron concretions. This subsoil section is composed of till or drift. Rounded fragments of various rocks entirely foreign to this section are common.

This type occurs over the greater part of the upland region of Carroll County. It occupies the lower slopes of both large and small drainage courses. Northwest of Tina a considerable area of rolling country has been mapped in which the Shelby loam persists over the crests, as well as on the slopes, of the series of large irregular ridges. The type is of glacial origin.

Owing to its topographic position and the sandy nature of the soil and heavy character of the subsoil, surface drainage is excessive and the run-off rapid, so that erosion is severe during times of heavy rains. Crops on the heavier areas are very seriously injured by protracted droughts.

The native forest growth consists principally of oaks, hickory, thorn trees, and wild cherry. Most of the arable land is cleared and in cultivation.

When well farmed this type is a very productive, though easily impaired soil. Corn, oats, timothy, clover, and wheat are the principal crops. Fruits produce as well on this as on the more valued upland soils. It is probable that small fruits and vegetables would prove profitable crops in some of the sandier sections. Lying as it does in strips following the stream courses, very few farms are composed entirely of Shelby loam. For this reason it may often be used advantageously for bluegrass pasture.

The Shelby loam, owing largely to its tendency to erosion, is not as highly valued as the upland types which it borders.

Eroded areas of this type may be bought for \$35 to \$50 an acre, although when in good condition it has a much higher value.

MANDEVILLE SILT LOAM.

The surface soil of the Mandeville silt loam consists of a mellow, smooth-textured, light-brown silt loam, from 12 to 14 inches deep. The subsoil grades through a light yellowish brown, compact silt loam into a friable silty clay to clay of the same color. At an average depth of 28 inches a slight gray mottling often occurs and persists throughout the lower portion of the subsoil. Very small iron concretions are found in the subsoil. The soil is generally rock-free, although in places limestone fragments occur on the surface and throughout the 3-foot section.

In the northwestern part of the county the soil to a depth of 8 to 14 inches consists of a light-brown silt loam varying in texture from medium to rather coarse. The subsoil grades slowly through a light yellowish brown silty clay loam into a rather heavy silty clay at 24 inches. At 30 inches the subsoil again becomes lighter textured and contains a larger proportion of silt and very fine sand. In many places slightly disintegrated shale is encountered at this depth. The yellowish-brown color of the subsoil persists throughout the section with very little variation. The greasy feel peculiar to shale soils is here characteristic of the subsoil. Irregular fragments of sandy shale and sandstone are always present on and near the surface in varying amounts. The rougher forested areas usually contain a higher percentage of rock material than the more level, cultivated areas.

This type has been mapped along the crests of some of the higher residual ridges and along the upper slopes of some of the upland prairie regions as they project into the more eroded hill section. As a rule it is bordered by a strip of Crawford silt loam frequently too narrow to be shown on a map of the scale used, and therefore included with it.

The topography of the Mandeville silt loam varies from gently rolling to rolling. Drainage is always adequate, and in places excessive. The soil is subject to damaging erosion and should be handled accordingly. Where the underlying rocks do not approach too near the surface it is a very drought-resistant soil.

Owing to the occurrence of limestone, the type has been considered as being largely of limestone origin, although its color and texture are very similar to those of the Knox silt loam. In the northwestern area occasional glacial pebbles scattered over the surface with the fragments of sandy shale and sandstone are evidence of the fact that the surface soil of this section is derived partly at least from the glacial drift, but even here the subsoil is largely derived from the underlying shale and sandstone formations. Originally the type was covered by a tree growth consisting largely of elm, walnut, oaks, and hickory. At present the greater part of this soil is under cultivation.

Its productiveness varies largely with the topography. The less rolling areas are usually the better. Good yields of corn, wheat, and clover are obtained. Corn usually yields from 20 to 45 bushels per acre. Crops suffer considerably during protracted droughts. The more rolling and broken areas are largely in pasture or forest. Several species of oak and hickory are the predominating trees. Bluegrass thrives on this soil. The chief needs of this soil are protection from erosion and the maintenance of the humus supply.

Land values are variable and fairly low. The distance from market unfavorably affects the selling price of most of the type.

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

Mechanical analyses of Mandeville silt loam.

No.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
342639.....	Soil.....	0.0	0.0	0.2	1.0	3.3	74.8	20.3
342640.....	Subsoil.....	.0	.1	.2	1.1	2.5	56.0	40.2

CRAWFORD SILT LOAM.

The soil of the Crawford silt loam to an average depth of 10 inches consists of a rich dark brown heavy silt loam to silty clay loam. Below this depth to 18 or 30 inches, where rock is encountered, the subsoil consists of a dark reddish brown, friable, silty clay loam to silty clay. Limestone fragments occur throughout the soil section and over the surface in varying quantities.

This type occurs mainly in many small areas in the rougher north-western part of the county, on top of ridges the slopes of which are occupied by Mandeville silt loam, on the upper slopes of ridges the crests of which are occupied by the latter type, and along some small draws. The rock from which the type is derived is a bluish-gray, fossiliferous limestone fairly free from chert.

The Crawford silt loam originally was largely in forest. Uncleared areas are at present occupied by a growth of elm, walnut, oak, and hickory.

There are a few areas where the type is too stony and rough for cultivation, on most of which bluegrass can be successfully grown. The greater part of the type is already in pasture. The soil is fertile and where tillable good yields of corn, wheat, and clover are obtained. Apple orchards also do well.

Owing to the small size of the areas occupied by the Crawford silt loam, no estimate can be made as to its value alone. The less stony areas, however, are highly valued.

WABASH SILT LOAM, COLLUVIAL PHASE.

The surface soil of the Wabash silt loam, colluvial phase, consists of 12 to 18 inches of silt loam varying in color from grayish brown to grayish black. When wet the soil appears black. The subsoil grades through a compact grayish silt loam to silty clay loam into a medium heavy silty clay loam to silty clay. Although considerable variation is encountered in the subsoil, the surface soil is very uniformly a mellow silt loam. A characteristic feature of this type is that the material gradually becomes heavier with depth, rarely changing abruptly from the silt loam of the surface to the silty clay of the lower section. Gray streaks and layers occur frequently through the soil section.

This type is confined to the inland streams of the county. It occupies the entire bottoms of the smaller streams and some of those of medium size, but in many cases only strips along the bottoms of the larger streams, especially near their outlets, the greater part of the soil in these bottoms being Wabash silty clay loam. Owing to the level topography of the larger bottoms and their meandering streams, they are usually poorly drained and represent the heavier phases of the Wabash silt loam, while the soil on the smaller streams is lighter. There are very few well-developed terraces or second bottoms along the inland streams, although the smaller stream bottoms are often rough and ridgy. Two or three small areas of grayish silt loam, underlain by a grayish-drab subsoil, probably belonging to the Waverly series, were encountered, but they were not of sufficient extent to justify their separation.

The type is subject to frequent overflows of short duration, which makes cropping rather uncertain. In some cases the streams have been straightened, thus carrying off the surplus water in a shorter time. By means of lateral ditches or tiling these areas might be made to dry out quickly after a period of high water.

The greater part of the type is kept in bluegrass pasture, to which it is excellently adapted. Often the bluegrass grows in the thinly forested areas. Corn is the principal crop grown, yielding as high as 80 bushels per acre on the better drained areas. Quite an extent of this soil is occupied by a heavy forest growth, consisting principally of black, white, pin, laurel, chestnut, red, and post oak, shellbark hickory, and papaw.

The Wabash silt loam, colluvial phase, is an alluvial soil and represents largely reworked loessial and glacial material coming mainly from the upland soils of the county. It is a remarkably fertile soil and will stand continuous cropping for years.

When sold alone the price of this type varies from \$60 to \$100 or more an acre, depending upon its drainage and location.

WABASH SILTY CLAY LOAM.

The surface soil of the Wabash silty clay loam consists of a dark-gray to black, fine-textured, heavy, micaceous silt loam to light silty clay loam, from 14 to 18 inches deep. The subsoil is a slightly heavy silty clay in the upper portion, becoming with depth a heavy clay. The subsoil layer is often locally called "joint clay" and is thought to be more permeable than the subsoil of the Wabash clay or "gumbo." The general color of the subsoil is a mottled drab and yellowish brown. Small, slightly depressed grayish spots occur in many places, the color of which is probably caused by poor drainage. During a dry season these areas produce as well as the rest of the soil, but with more than the usual rainfall they are noticeable on account of their inferior plant growth.

The Wabash silty clay loam occurs throughout the Missouri River bottoms in irregular bodies lying just above the Wabash clay, and usually forms a sort of escarpment or lies as low, rather narrow ridges running through the clay type. The topography varies from nearly flat to very gently undulating. Although a bottom soil, the type is reasonably safe from overflow, except in its lowest areas. Small areas of this type have also been mapped along some of the larger inland streams, where they are subject to overflow during any period of high water. These latter areas are as a rule cleared and left in bluegrass pasture, to which they are very well adapted.

Practically all of the Wabash silty clay loam occurring in the Missouri River bottom is cleared and in cultivation. It is as a rule easily tilled, breaking down into a very mellow seed bed. There is no doubt that tiling would prove profitable in these areas. Excellent crops are usually produced and the strength of the soil is lasting. Corn, wheat, oats, and the various grasses and clovers are grown.

The better areas of this type have a high value, being considered the second best land in the county.

WABASH CLAY.

The surface soil of the Wabash clay consists of a very dark, usually black, friable clay loam to clay, from 8 to 10 inches deep, and having a high content of organic matter. The subsoil is a drab-colored plastic clay, becoming lighter in color and more plastic with depth, and having numerous thin streaks of brown or red, which sometimes cause a slight mottling. In places there is a very small quantity of very fine sand in the lower subsoil. Sand in appreciable quantities, however, is rarely encountered at a depth of less than 6 feet.

The Wabash clay, locally known as "gumbo," represents mainly the lower, heavier portion of the bottoms of the Missouri and Grand Rivers and Turkey and Wakenda Creeks. In the Missouri River

bottoms, where the greater part of this type occurs, it lies back from the river front near the bluffs. The largest area mapped is west of Norborne.

The material from which this soil has been formed was deposited by standing water; hence the fine texture of the particles. Although seldom actually overflowed by the Missouri River, these heavy areas originally stood under water during the greater part of the year, their only outlet being large, shallow lakes and wide, slow-moving streams, most of which flowed into Wakenda Creek. The native vegetation consisted of the various water-loving grasses. During recent years some of these areas have been drained by means of large ditches and the drainage of others is in progress. Although contrary to the general impression, it has been demonstrated that the drainage of these areas may be successfully completed by the use of tile.

The Wabash clay is a very productive soil, though cultivation is difficult, especially for the first few seasons after reclamation. Owing to its tendency to puddle or bake, this soil should not be handled when wet. Disking the stubble before the fall plowing has given very good results, causing the soil to turn easier and to break down into better tilth.

Corn yields as much as 60 to 80 bushels per acre. Wheat and oats have a tendency to make too rank a growth of straw but under favorable conditions excellent yields are obtained. Timothy and red clover usually produce between 1 to 2½ tons per acre of good quality hay. Under present conditions hay is undoubtedly the most profitable and satisfactory crop for these areas. Areas used for bluegrass pastures are very productive. Some areas of the type still support the original growth of swamp grasses.

Improvements on the farms over this type are only fair, especially the fences, as is the case over the greater part of the bottoms—primarily a grain-farming section.

The prices of land of this type have advanced rapidly during the last few years.

BUCKNER LOAM.

The surface soil of the Buckner loam is a very dark brown to black loam, in many places approximating closely a very fine sandy loam in texture and having a depth of 14 to 18 inches. The subsoil grades quickly from a very dark brown loam in the upper part through a lighter brown loam into a light yellowish brown very fine sandy loam at 30 inches, becoming sandier with depth.

This type occurs in small irregular-shaped bodies, the largest of which is southwest of Carrollton. It lies as rather wide gently undulating ridges or escarpments, considerably higher than the heavy clay soils. Natural drainage on this type is excellent and the soil is easily tilled.

The Buckner loam is generally conceded to be the most productive soil in the county. There is practically no danger of overflow and crops are as a rule not seriously injured by prolonged wet or dry seasons.

Very little of this soil is used for any other purpose than grain farming. Wheat yields from 18 to 30 bushels and corn from 60 to 100 bushels per acre, depending largely upon the condition of the soil. In several instances fields have deteriorated through continuous cropping to corn or wheat. Red clover makes a heavy growth and is used extensively in crop rotations. Alfalfa does well, although grown only on a small acreage at present.

Should the trucking industry ever assume importance in this county it is probable a great deal of this soil will be used for the production of such crops, owing to its fertility, earliness, excellent moisture conditions, and nearness to shipping points.

Land values on this type are high, \$200 an acre having been repeatedly refused for some of the best of it. It is very unlikely that under normal conditions any of it could be bought for less than \$160 an acre.

BUCKNER VERY FINE SANDY LOAM.

The surface soil of the Buckner very fine sandy loam consists of a dark-brown to black very fine sandy loam, from 15 to 18 inches deep, which in places is rather coarse and gritty. The subsoil is a somewhat lighter brown very fine sandy loam to a depth of 26 to 28 inches, where it becomes a light yellowish brown fine sandy loam to fine sand. Occasionally areas have been encountered where the black color persisted throughout the soil section.

The Buckner very fine sandy loam, locally known as "black sand," occurs as narrow ridges slightly above the general level, extending usually along the edge of a former escarpment and very seldom occurring near the present channel of the Missouri River. This soil is naturally productive and under careful management remains so after long-continued cropping. Drainage is good and the soil warms up and becomes tillable early in the spring.

At present the soil is mainly devoted to the production of general farm crops. It is well suited to various truck crops and in many cases these would no doubt prove more profitable than the crops now grown.

SARPY CLAY.

The Sarpy clay consists of 16 inches of black clay, underlain by a light yellowish brown fine sandy loam, which passes at lower depths into a fine sand of somewhat lighter grayish color. Considerable variation occurs in the depth of the soil and the texture of the subsoil.

This type owes its formation to the deposition of fine material by standing or slowly moving water upon sand bars and flats. Much organic matter has been added through the decay of vegetation.

The topography of the Sarpy clay is level to slightly ridgy, the ridges being small and irregular and having a small quantity of sand in the immediate surface. Owing to the small size of these ridges it was not considered practical to attempt a separation unless they predominated, in which case they were mapped as the Sarpy clay loam. This type occupies a higher level than that of the Wabash clay. Owing to the open structure of the subsoil, drainage is fair.

The greater part of this soil is under cultivation. Good yields of corn, wheat, oats, clover, timothy, and bluegrass are obtained. Several small fields of alfalfa were observed, usually on areas of shallow clay soil with a distinctly sandy subsoil. Owing to the difficulty in handling the heavier areas of this type they are not so well adapted to corn as to the small grains. Fall plowing is practiced to a considerable extent, the freezing and thawing during winter serving to break down and mellow the soil for the following season. Care must be taken not to puddle the soil by working it when too wet. With favorable fall weather the soil can be worked into a fine seed bed. By following the binder with a disk harrow a slight surface mulch is obtained, which tends to make plowing easier and gives a greatly improved tilth.

Owing to its superior drainage condition the Sarpy clay is more highly valued than the Wabash clay and is at present in a better state of cultivation.

SARPY CLAY LOAM.

The Sarpy clay loam to a depth of about 14 inches consists of a dark-brown to nearly black clay loam. This is underlain by a light yellowish brown fine sandy clay, which grades through a yellowish fine sandy loam into a fine to very fine sand. The sand content of the surface soil is fine to medium in texture. The type is variable in both depth and texture of soil.

Several small, scattered areas of the Sarpy clay loam occur in the river bottoms. The surface is generally uneven, being composed of alternating small, irregular ridges and depressions. The ridges are slightly sandy, the depressions often as heavy as Sarpy clay, but not of sufficient size to be separated on the map. There are a few areas in which the topography, like that of the Sarpy clay, is level and flat.

Drainage is good and the larger content of coarse material tends to make it more tractable than the Sarpy clay.

All of the Sarpy clay loam mapped is in cultivation and produces good crops of corn, wheat, clover, and alfalfa. It is adapted to practically the same agricultural methods as the Sarpy clay and is held at about the same price.

SARPY VERY FINE SANDY LOAM.

The Sarpy very fine sandy loam consists of a light-brown to brown very fine sandy loam from 12 to 15 inches deep. The subsoil is a grayish-yellow very fine sandy loam, in places becoming with depth a grayish very fine sand. The variation in color of the surface results from the varying humus content.

This soil occurs as a low ridge, following in general the course of the river and does not, as a rule, extend a great way back into the bottom. It is well drained and may be handled earlier and with much greater ease than the heavier soils.

At present most of the type is cleared, some small areas being sparsely covered with cottonwood, sycamore, hard and soft maple, elm, hickory, and pecan trees. It is said to have been originally contained in an area supporting a heavy growth of pecan and hard maple.

Corn, small grains, clover, and alfalfa constitute the principal crops and give excellent yields. Very little of the type is in pasture.

In the eastern end of the bottoms a considerable acreage is devoted to onions, which are very profitable and will probably be more extensively grown in the future. This is a crop requiring intensive cultivation and much hand labor, and at present is seriously affected by the scarcity of skilled workers.

Potatoes are also profitably grown, mainly in the eastern bottoms. Watermelons are grown extensively, usually near the river, and cantaloupes are produced, though on a smaller acreage. Both find a ready local market.

Sarpy very fine sandy loam, heavy subsoil phase.—The surface soil of the heavy subsoil phase of the Sarpy very fine sandy loam consists of a light grayish brown to brown very fine sandy loam, with a depth of 5 to 10 inches, grading abruptly into a drab-colored plastic medium heavy clay. This clay layer persists to a depth of 16 to 24 inches, the lower 12 to 20 inches of the 3-foot section being composed of a light grayish yellow very fine sandy loam to very fine sand.

The topography of this phase is practically identical with that of the main type and the agricultural value of the two is about the same.

RIVERWASH.

Areas along the Missouri River composed of alternating sand bars, sandy flats, and depressions covered with a silty clay have been mapped as Riverwash. Owing to the frequency of overflows and the consequent uncertain yields, these areas are not often cultivated. They are usually covered with a growth of willow.

Along Bowdry Lake to the river and to the southwest along the river two small areas were included in Riverwash which but for their

limited extent would have been mapped as Meadow. Along the river these areas are covered with a growth of trees, largely cottonwood. The soil is a mixture of clay and sand.

Drainage.

In a bottom comprising so large an area as that of the Missouri River bottom lands in Carroll County it is quite natural to expect a considerable amount of heavy poorly drained land. In the formation of the bottoms the river, having deserted its original channel and moving away, has gradually thrown up a natural levee originally near its course, leaving the older bottom at a lower level. This area being flooded only by back water has received a deposit varying from 4 to 14 feet of the finest textured soil particles. It is locally known as "Gumbo." A considerable amount of upland drainage, mainly through Wakenda Creek, is carried down upon the low area and forced to follow this low-lying area along the foot of the bluff to near White Rock, where it flows into the river. As a result, during the winter and spring months thousands of acres of this soil have been wet and in no shape for cultivation. The work that has been done and is being done through means of dredged ditches is to carry away this surplus drainage water and reclaim the heavy areas.

Three drainage districts have been organized—two wholly and one partly contained in this county.

The first, the Norborne land drainage district, after much time and trouble was finally put in about 1902 and 1903. Starting in Ray County it swings to the south of Norborne.

The second, Sugartree drainage district, drains a territory in Sugartree Township into Bowdry Lake. It was dug about six years ago.

The third, known as drainage district No. 3, Carroll County, is composed of two branches, one following Turkey Creek, the other following Booker Slough, the two uniting and following Wakenda Creek to its outlet. This system amounts to practically a straightening out of the present drainage courses.

A large tile lateral is being placed from Norborne south to Moss Creek.

Eventually that part of Moss Creek not yet dredged should be and likely will be straightened, thereby forming a very complete drainage system.

The drainage already completed has reclaimed vast areas formerly of little agricultural value and much further good will undoubtedly be accomplished with the completion of the present ditching, which will be some time during 1913.

Several levees along the river front have been thrown up in years past, and some are to be put in soon. Considerable trouble is often caused by changing currents in the river, which cut out sections of the levees, usually during the receding floods.

SUMMARY.

Carroll County lies in the rolling prairie region of northwest Missouri and comprises an area of 703 square miles, or 449,920 acres.

It is traversed by railroads with direct lines to the Kansas City, St. Louis, and Chicago markets.

The climate is moderate, although marked by pronounced extremes in both temperature and rainfall. It is a humid region, with an average rainfall of about 38 inches. Its growing season of 190 days is sufficient for all general farm crops.

There are two general physiographic divisions in the county, the rolling prairie and rougher rolling hill section of the uplands, and the broad, nearly level bottom lands, part of which are poorly drained.

The bottom lands of Carroll County occupy a greater area than those of any other county in the State along the Missouri River. They are seldom subjected to overflows from the river. Large drainage ditches have been dug through the poorly drained parts of the bottoms. These are being gradually extended.

Agriculture is practically the only industry in the county. Large quantities of corn and wheat are grown, most of the former being fed in the county. A large part of the latter is shipped to outside markets. Clover is grown over the whole county. Oats, alfalfa, rye, and millet are secondary crops. Bluegrass grows luxuriantly. Truck farming is developing rapidly, the principal crops now being tomatoes, potatoes, onions, and melons.

Eighteen soil types, including Riverwash, and 5 type phases were mapped in the county.

The Knox silt loam, a true loess soil, is a productive type, but subject to serious erosion. It comprises a belt of country 1 to 4 miles wide along the bluff. The Knox silt loam, colluvial phase, is a colluvial wash from the loessial bluffs. It is suited to grain and truck crops.

The Marshall silt loam extends as a wide belt back of the Knox silt loam. It is a dark-colored productive soil, well adapted to general farm crops. The Marshall silt loam, terrace phase—a loessial deposit over an old stream terrace—is a productive, highly valued soil.

The Putnam silt loam, rolling phase, occupies a large part of the northern upland region. It is a good corn and hay soil. Stock farming is the principal industry.

The Shelby loam is derived from glacial till, which is exposed along slopes of the upland streams and is well adapted to all general crops.

The Mandeville silt loam, mainly a residual soil derived from sandstone and shale, with some admixture of glacial material, occurs in the northwestern part of the county. It is a productive type, and in the less rolling areas well suited to general farm crops.

The Crawford silt loam is a strong soil, well adapted to bluegrass pasture.

The Wabash and Sarpy series are alluvial soils, mainly in the Missouri River bottom.

The Wabash silt loam, colluvial phase, has been mapped along the inland streams. It is very productive but subject to overflow.

The Wabash silty clay loam as mapped in the Missouri River bottom is well drained and productive. Along the inland streams it is poorly drained and generally left in bluegrass pastures.

The Wabash clay is a heavy black soil, with a high content of organic matter. It is very productive when drained, but is hard to handle.

The Buckner loam is a fertile, dark-colored, well-drained soil, and is very highly prized.

The Buckner very fine sandy loam occurs usually closely associated with the loam type, and is a fertile though not very durable soil.

The Sarpy clay is a productive heavy clay soil underlain by fine sand to compact silty clay loam.

The Sarpy clay loam is slightly more friable than the clay type. It forms only a small area in this county.

The Sarpy very fine sandy loam is a fertile, light-colored soil, well suited to general farming and trucking. The heavy subsoil phase has about the same agricultural value as the main type.

Riverwash has been mapped along the Missouri River. It contains one or two small areas that might have been classified as Meadow.

Erosion and drainage are important problems in the county. More organic matter should be incorporated in some of the thinner soils. A system of rotation including the growing of clover is generally followed.

Although land is held at high prices, it yields profitable returns when properly managed.

The labor question is being met in a way by the use of more improved machinery.

[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.]

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