

Issued May 5, 1916.

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;
M. F. MILLER, IN CHARGE SOIL SURVEY.

SOIL SURVEY OF JOHNSON COUNTY,
MISSOURI.

BY

B. W. TILLMAN, OF THE U. S. DEPARTMENT OF AGRICULTURE,
AND C. E. DEARDORFF, OF THE UNIVERSITY
OF MISSOURI.

CURTIS F. MARBUT, INSPECTOR IN CHARGE.

[Advance Sheets—Field Operations of the Bureau of Soils, 1914.]



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1916.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., October 6, 1915.

SIR: In the extension of the soil survey in the State of Missouri a survey was undertaken in Johnson County and completed during the field season of 1914. This work was done in cooperation with the University of 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 and map covering this survey and to recommend their publication as advance sheets of Field Operations of the Bureau of Soils for 1914, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

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

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MAP.

Soil map, Johnson County sheet, Missouri.

SOIL SURVEY OF JOHNSON COUNTY, MISSOURI.

By B. W. TILLMAN, of the U. S. Department of Agriculture, and C. E. DEARDORFF, of the University of Missouri.

DESCRIPTION OF THE AREA.

Johnson County is situated in the western part of Missouri, in the residual prairie section of the Great Plains region. It lies slightly north of the east and west median line of the State and is one of the second tier of counties from the Kansas line. It is bounded on the north by Lafayette County, on the east by Pettis County, on the south by Henry and Cass Counties, and on the west by Cass and Jackson Counties. The county is roughly rectangular in outline and has a length from east to west of 33 miles and a width from north to south of 25 miles. Its area is 831 square miles, or 531,840 acres.

Johnson County comprises two physiographic divisions—the upland and the lowland. The upland is by far the more extensive, comprising about nine-tenths of the area of the county. Topographically it is rolling rather than level or undulating, although areas of considerable extent are comparatively level. The surface configuration indicates clearly the geological structure and relative resistance to weathering processes of the interbedded shales, sandstones, and limestones which comprise the underlying rocks of the region.

A central belt and the southeastern and southwestern parts of the county are somewhat smoother than the remainder. The central belt includes the immediate valley of Blackwater River and a lowland belt adjacent to it, especially the country lying northeast of Warrensburg. The lowland belt is developed on a bed of soft shales lying beneath a series of more resistant limestones which form the adjoining higher country to the south, the limestone outcropping along the southern border of the lowland at the top of a low but well-defined escarpment. The western boundary of the lowland belt in the vicinity of Warrensburg is formed by the moderately resistant



FIG. 1.—Sketch map showing location of the Johnson County area, Missouri.

Warrensburg sandstone. The southwestern smooth area is likewise developed on a bed of soft shales, which is higher than that forming the central belt. It lies in front of an escarpment which barely enters the western part of the county, and which constitutes the eastern boundary of a high plateau in Jackson and Cass Counties. The smooth area in the northeastern part of the county extends over a series of limestone beds. It is a low plateau, over somewhat resistant limestone, which has not yet been dissected.

The extreme northwestern part of the county is rougher than the other sections, excepting a narrow strip along Clear Creek. The roughness is accentuated by many outcrops of limestone.

The county is well drained. The largest stream is Blackwater River, the main stream being formed by the junction of two branches, the North and South Forks. Big Creek drains the southwestern part of the county. The extreme northwestern part and a few small areas along the northern boundary of the county drain northward. The watershed which separates the Blackwater River and Big Creek basins extends from a point northwest of Kingsville in a southeasterly direction to Chilhowee, from which point it continues eastward along the line of the Missouri, Kansas & Texas Railway about a mile north of the southern boundary of the county.

The first settlement in this section was made in 1827, at the site of the present village of Columbus, the region being at that time a part of Lafayette County. Johnson County was organized in 1837. Most of the early settlers came from Virginia, Kentucky, the Carolinas, and Tennessee. The population is reported in the 1910 census as 26,297.

Warrensburg is the county seat. Its population as reported in the 1910 census is 4,689. It is located on the main line of the Missouri Pacific Railway between St. Louis and Kansas City, a little east of the geographic center of the county, and is the site of the State normal school for the second district of Missouri.

Holden, the second largest town in the county, has a population of 2,007. It has the best railroad facilities of any town in the county, being located on the Missouri Pacific and the Missouri, Kansas & Texas Railways. It is the main distributing point for the western part of the county and is noted for its creamery products and for its large poultry shipments.

Knobnoster, with a population of 670, is located in the eastern part of the county on the Missouri Pacific Railway, and is the main distributing point for that section. The manufacture of high-grade brick is an important industry at this place. Montserrat, Center-view, Kingsville, Chilhowee, Leeton, and Sutherland are smaller

railroad towns. Other small towns are Columbus, Pittsville, Fayetteville, and Hoffman.

The county as a whole is well supplied with transportation facilities. Only the northern part, in the vicinity of Columbus, is rather remote from railroads, the distance from some points in this section to the nearest shipping point being about 11 miles.

The Missouri Pacific Railway crosses the central part of the county. A branch line of the Missouri, Kansas & Texas Railway parallels the southern county line, at a distance of 1 to 2 miles, from Pettis County to Chilhowee, from which point it extends diagonally to Holden and thence southwestward across the county line. The Chicago, Rock Island & Pacific parallels the Missouri, Kansas & Texas in the southern part of the county, and the Kansas City-Springfield Branch of the St. Louis & San Francisco Railroad crosses the extreme southwestern part of the county.

The public roads usually follow the land lines and for the most part are well graded. Culverts are constructed of concrete, and steel bridges span the streams.

A good telephone system reaches all parts of the county, and all sections are served by free rural delivery of mail.

CLIMATE.

The winters are mild and short, and periods of extremely cold weather usually are of only a few days' duration. The falls are characterized by long periods of warm, open weather, which often continues to the middle of December.

The mean annual rainfall is 36.50 inches. This, although less than the rainfall in the eastern part of the State, is sufficient for the successful production of corn and other crops if the soil moisture is properly conserved. The average rainfall within the growing season is about twice as heavy as in the other months of the year. Droughts of four to six weeks' duration sometimes occur in summer.

The mean annual temperature is 54.7° F. The mean for the months of June, July, and August is 76.3° F. The average date of the last killing frost in the spring is April 18 and of the first in the fall October 17, giving a normal growing season of 182 days. The earliest recorded date of killing frost in the fall is September 29 and the latest in the spring May 4. Fruit is sometimes injured by late spring frosts. Such frosts are especially injurious to peaches. Frequently there are periods of wet weather in the spring which delay the planting and cultivating of crops, particularly on the soils where drainage is deficient. The climate as a whole, however, is well suited to general farming.

The following table, compiled from the records of the Weather Bureau station at Warrensburg, gives the normal monthly, seasonal, and annual temperature and precipitation of the county:

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

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.
	° F.	° F.	° F.	Inches.	Inches.	Inches.
December.....	33.9	68	-14	1.83	Trace.	0.88
January.....	28.0	77	-14	1.79	1.49	0.93
February.....	30.3	76	-26	2.03	0.94	2.65
Winter.....	30.7			5.65	2.43	4.46
March.....	42.7	91	2	2.51	1.23	1.64
April.....	55.9	92	17	3.01	3.66	2.00
May.....	65.2	92	28	4.75	5.44	7.28
Spring.....	54.6			10.27	10.33	10.92
June.....	73.9	103	45	5.14	2.32	13.29
July.....	78.5	110	54	4.23	Trace.	5.60
August.....	76.6	104	49	3.64	1.62	5.67
Summer.....	76.3			13.01	3.94	24.56
September.....	69.6	100	30	3.17	1.48	3.02
October.....	57.9	94	26	2.47	1.86	5.46
November.....	43.9	79	9	1.93	0.62	4.67
Fall.....	57.1			7.57	3.96	13.15
Year.....	54.7	110	-26	36.50	20.66	53.09

AGRICULTURE.

Johnson County is predominantly agricultural in its industries. The early settlers of the region located along the small streams, which were bordered on both sides by forested areas ranging from 1 mile to 3 miles in width. They cleared a few acres of land, using the timber for fuel, fence fails, and the construction of log cabins. It was thought impossible to break the turf of the prairie land, and for this reason the prairie was used for cattle ranges. Few of the settlers attempted to cultivate more than a few acres, growing corn and vegetables for food.

Corn soon became the principal crop, although wheat, flax, oats, and rye received early attention, and some tobacco was grown. The development of the county was rapid until the Civil War, which arrested agricultural progress. From 1865 until the panic of 1873 land

values rapidly advanced and there was a great influx of settlers from the States to the east. The period from 1873 to 1878 was one of general business depression, accentuated by crop failures and crop injury by insects. The financial interests of the county were in a precarious condition, a number of banks failed, and many farm mortgages were foreclosed. Since 1880, however, the agricultural development of the county has been steady.

The extensive range lands of the county made the raising of live stock profitable from the beginning. In later years corn growing was extended, but it was difficult to sell the crop, and the feeding of hogs and cattle for market was undertaken and developed rapidly into a profitable industry. This combination of the live-stock industry and grain production is the prevailing type of agriculture in the county at the present time, differing from the earlier form only in that it includes the production of a greater variety of grain and hay crops and more systematic methods of handling the stock. With the exception of wheat, practically all the crops grown in the county are fed to stock.

Corn is the most important crop. The 1910 census reports a total of 133,995 acres in corn in 1909, with a production of 3,957,990 bushels. In 1912, according to the Missouri Crop Review, published by the Missouri State Board of Agriculture, the total area in corn was 136,861 acres, with a total production of 5,200,718 bushels. The production for 1913 was materially less than this, owing to the dry season. The acreage in corn has increased in recent years, owing partly to the extensive reclamation of bottom lands along Blackwater River and other streams. Nearly all the surplus corn is fed to live stock, mainly cattle and hogs, the two often being fed in the same lot. Corn binders are in rather general use. Large quantities of ensilage are fed, many farms having two or more silos. The corn which is not used for ensilage or fodder is either "hogged off" or snapped in the field. In the spring the stalks are plowed under.

Some attention is given to corn breeding, and good varieties for the localities in which they are to be grown are easily obtained. Much interest is taken by some farmers in exhibition contests, resulting in greater care in selecting and testing the seed by exhibitors. Over the county as a whole, however, seed selection receives but little attention. Of the white varieties of corn the Boone County White and Johnson County White have been found by the State experiment station to do best in this locality, while of the yellow varieties Reids Yellow Dent and Leaming are preferred. The Boone County White and Leaming are large-growing varieties and seem to be best adapted to the bottom lands.

Next to corn, wheat is the most important crop. In 1909, according to the census, a total of 27,808 acres was sowed to wheat, produc-

ing 365,063 bushels. In 1912 the Missouri Crop Review reports 27,245 acres, with a production of 463,165 bushels. In 1913 a total of 508,351 bushels was reported from 29,903 acres. The greater part of the wheat is ground into flour at local mills. The wheat is of good milling quality.

The Hessian fly sometimes causes injury to the wheat crop, and late sowing is frequently resorted to to avoid such injury. Occasionally farmers sow small patches early to attract the fly, thus saving the main crop, which is sown later.

Land is generally plowed for wheat in the late summer or early fall. Early summer plowing is highly advisable, but is not extensively practiced on account of the pressure of other work at this time. The harrow, disk, and roller are used in preparing the land. The wheat is seeded with drills, usually at the rate of about $1\frac{1}{4}$ bushels per acre. A few farmers use a complete fertilizer on wheat at seeding time, generally with good results. There is some damage by smut, but no extensive efforts are made to combat the disease. The crop is thrashed from the field over the greater part of the county, although the grain is stacked in some places. No spring wheat is grown. At present very little wheat of recognized varieties is sown.

Oats were grown on 20,397 acres, with a production of 466,699 bushels, in 1909, according to the census. The area in oats in 1912 is reported by the Missouri Crop Review as 15,298 acres, with a production of 566,026 bushels. The profits from this crop vary widely. In some years it is an almost complete failure, largely on account of injury from rust. Smut is also injurious at times. Through the introduction of hardier varieties, better yields are now obtained. The crop is used largely for home feed. It is important as a nurse crop. The Texas Red Rustproof and Kherson varieties do best.

Rye was grown in 1909 on 241 acres, with a production of 2,422 bushels. Kafir and milo were grown on 551 acres, producing 12,206 bushels. Little barley is grown in the county.

The production of hay is an important industry. According to the census, 63,592 tons were produced on 56,657 acres in 1909. Of this quantity 24,018 tons were timothy and 32,214 tons timothy and clover mixed. Timothy is extensively grown on all the soils of the county. It does especially well on the Summit silt loam. A method of seeding timothy which has met with good results consists of sowing the seed broadcast in a cultivated field of corn or other crop, no seed bed being prepared. The prevailing practice is to sow the seed in the fall, but spring sowings are equally successful. Sometimes the method of seeding on cultivated ground is objectionable on account of the rough surface, especially when the crop is grown for hay. Where the timothy is grown for pasture the rough surface

is not so objectionable a feature. Smooth cultivation of the corn crop reduces the unevenness of the surface to a minimum.

According to the census, red clover was grown on 4,652 acres in 1909, with a production of 5,320 tons of hay. In addition there were 28,910 acres of mixed clover and timothy. The prevailing system of live-stock farming, under which land is often left in pasture for three or four years, has kept most of the soils in a fairly productive condition without the extensive use of leguminous crops. Clover is receiving more attention, however, as the productiveness of the soils decreases. It can be grown on all the soils of the county. Where a stand is not easily obtained an application of 2,000 to 4,000 pounds of ground limestone per acre is helpful.

In the last few years the production of cowpeas has received considerable attention. This crop is grown to a greater or less extent in all parts of the county and produces good yields. Many farmers drill the seed in the corn and use the vines either for ensilage with the corn or for pasturage. The cowpeas are seeded between the middle and the last of June. The Whippoorwill, Black, Clay, and New Era varieties do well in this region. The crop is almost as effective as red clover in increasing the productiveness of the soil.

The 1910 census reports 352 acres in alfalfa, with a production of 970 tons of hay. The acreage has increased considerably since that time. This crop can be grown successfully on a wide range of soils, provided they are well drained, well supplied with plant food, and in good tilth. Liming is frequently necessary. The alfalfa is grown mainly on the alluvial soils, where it does particularly well.

Increasing attention is being given to the production of sweet clover. This crop thrives under a wide variety of soil conditions, frequently making a vigorous growth on soils that are unproductive of the ordinary farm crops, on clay embankments, and along the roadsides. It does best on soils that are well supplied with lime, and it is frequently necessary to apply this constituent to fields which have been cropped for a number of years. This crop supplies a cheap and efficient means of increasing the organic-matter and nitrogen content of the soils. It is also valuable in preventing washing and gullyng on hillsides, as it has a very deep root system, which penetrates the heavy subsoils.

According to the census, sorghum was grown on 802 acres, with a production of 3,627 tons, in 1909. Tobacco was grown on 10 acres, producing 5,340 pounds.

Little fruit is grown on a commercial scale, although there are some successful commercial orchards. The local demand for fruit is largely supplied within the county. There are good markets for fruit, but the climatic conditions are not particularly favorable to its successful production on a large scale, the frequent occurrence of

late spring frosts following warm periods being very damaging, particularly to peaches. Little systematic care is given to the small orchards, and insect pests and fungous diseases are quite prevalent. According to the census, 100,223 bushels of apples and 10,198 bushels of peaches and nectarines were produced in 1909. The value of all fruits and nuts produced in that year is given as \$80,969.

Irish potatoes were grown on 1,150 acres, producing 109,000 bushels, and sweet potatoes and yams on 35 acres, producing 4,073 bushels, in 1909. Strawberries, onions, tomatoes, and other truck crops are grown in small patches and do well.

The annual value of live stock sold or slaughtered and live-stock products sold is reported in the 1910 census as \$3,418,250. The census reports a total of 21,437 cattle, 5,902 horses and mules, 89,852 hogs, and 12,552 sheep and goats sold or slaughtered. Besides the large number of cattle raised each year, many feeders are shipped in and fattened for market. The quality of the cattle is generally good. There are many herds of purebred beef cattle, Herefords and Short-horns predominating.

Creameries have been established at Holden and Warrensburg and the marketing of dairy products receives considerable attention. There are some dairy herds in the county in which the Jersey breed predominates, as well as several purebred Jersey herds. The greater part of the milk, however, is produced from grade beef cows. The excellent bluegrass pastures, the abundance of fresh water, the absence of danger from disease, the low cost of providing buildings and feed, and good markets favor the development of the dairy industry.

Practically all the farmers have a few horses and mules for sale each year. The mules are of good size and command high prices. The horses are not so good as the mules, although purebred stallions are being introduced and the grade is being materially improved.

Hog raising is a very important branch of the live-stock industry. Large numbers of hogs are kept in conjunction with beef cattle. Many purebred hogs are kept and the stock as a whole is of good quality. Poland China, Duroc Jersey, and Chester White are the most important breeds. The development of hog raising has been seriously retarded by the prevalence of cholera and much attention is now given to inoculation and other measures for combating this disease.

There are several flocks of sheep in the county, but sheep raising is not receiving much attention. Owners complain of the destruction of sheep by dogs.

Poultry is kept on all the farms and constitutes an important source of income. Large flocks of turkeys and some ducks and geese

are kept. There is a good local demand for poultry products, and much attention is given to the improvement of poultry breeds. Co-operative egg marketing resulted in an average price of 3 to 5 cents per dozen above local prices being received for eggs during 1914.

The cultural methods followed in Johnson County are well adapted to the prevailing soil and climatic conditions. Pasture lands are frequently plowed in the fall, and this practice is very beneficial where there is no danger of erosion. With the increase in the number of live stock in the county larger quantities of manure are being produced and returned to the land. The productiveness of the soils is materially increased by the application of manure and the plowing under of green leguminous crops.

The crop rotation most generally followed consists of corn for 1 year or 2 years, followed by wheat or oats; the small grain is followed by clover or clover and timothy for 2 years or more, after which the land is returned to corn. Frequently land is left in sod for 3 or 4 years before planting to corn. The need of leguminous crops in the rotation, not only to supply feed rich in nitrogenous constituents for the live stock, but also for the improvement of the soils, is generally recognized.

According to the census of 1910, only 65 per cent of the farms in the county are operated by owners. Recent studies by the Department of Farm Management of the Missouri Agricultural Experiment Station¹ in four townships in the western part of the county show that owners of farms grow less grain and devote more land to pasture and hay production than part owners and tenants. The tenant devotes 50 per cent more land to corn than the owner and nearly twice as much land to wheat and oats. The yield of corn is about 15 per cent lower on the tenant farms than on farms operated by the owners, with a smaller difference in the wheat yield, and the yield of oats is about one-third lower. In general the farm owner derives one-fourth of his income from the sale of crops and three-fourths from live stock, while the returns to the tenant from the two are about equal. The owners buy back in the form of feed about one-half the quantity of the crops sold, while the tenants buy back about one-sixth. The prevailing system of land tenure is not such as tends to bring about a general improvement in the productiveness of the soils. Rents range from \$3 to \$8 an acre, depending on the location and productiveness of the land. When land is worked on shares the owner usually receives one-third of the crops.

In places where the surface run-off is rapid considerable erosion has occurred. This can be checked by growing winter cover crops, such as rye, and by the incorporation of organic matter. With the

¹ Bul. 121, College of Agr., University of Missouri.

formation of gullies the prevention of erosion becomes more difficult. A method employed with considerable success in this county consists of building a dam of earth or stone across the gully in the lower part of the field to hold the surface run-off. A pipe passes through the dam and connects with an upright pipe on the upper side to conduct the water away after it reaches the height of the vertical pipe. The sediment is checked by the dam and soon fills the depression. Sometimes several dams are constructed along the course of a single gully. A tile drain is usually so placed as to dispose of the water left standing below the upright pipe.

The average size of the farms is reported by the census of 1910 as 132.6 acres and 87 per cent of the land in farms is reported as improved. Land values range from \$40 to \$150 an acre, depending mainly on location. Over a large part of the county land sells for \$60 to \$70 an acre.

Farm labor is difficult to obtain. Monthly wages range from \$25 to \$40, with board and lodging. Day laborers receive from \$1.50 to \$2 a day. Labor-saving machinery is in general use.

A condition of general prosperity prevails throughout the county. The organization of rural districts for the purposes of cooperative buying and selling and the promotion of agricultural enterprises, such as cooperative live-stock breeding and the prevention of live-stock diseases, is receiving attention in different parts of the county. One of the first rural high schools in the State was established in Johnson County. A county farm adviser is employed to study the agricultural conditions of the county with a view to their improvement. The general tendency is toward a more permanent and scientific system of agriculture.

SOILS.

The soils of Johnson County are classed in two general groups, upland soils and lowland soils.

The upland soils are of residual origin and are derived from the immediately underlying rocks, which belong to the Pennsylvanian division of the Carboniferous and consist of alternating strata of limestone, shale, and sandstone. Geologically the county is made up of the Cherokee shales and sandstones, the Henrietta limestones and shales, the Pleasanton shales, the Bethany Falls limestone, and the Warrensburg sandstone. These five formations enter into the composition of the soil material of the uplands. No soil type is derived entirely from any one rock formation, as there is always more or less mixing of material from different areas, and in addition the soils derived from different formations are sometimes nearly enough alike to be classed in the same series. The Crawford soils, for ex-

ample, are derived from limestone of both the Henrietta and the Bethany Falls beds. There is a general relationship, however, between the soils and the geological formations.

The Cherokee shale lies in the extreme southeastern part of the county and in the Blackwater lowland belt and consists chiefly of shale and sandstone, with a number of important coal beds and several thin limestone beds, some of which thicken greatly in the southeastern quarter of the county. The shale of this formation gives rise to the Oswego and Cherokee soils.

The Henrietta limestone occurs in the southeastern part of the county west of the area of Cherokee shale. It forms conspicuous ledges in that vicinity. This formation also outcrops in the southwestern and northeastern parts of the county along the main streams and along the escarpment bounding the south side of the central lowland belt. It consists of about 70 feet of interbedded limestone and shale. The limestone gives rise to the Crawford soils.

The Pleasanton shale is the surface formation in the western part of the county. The formation consists of about 175 feet of shale and sandstone, with one or two thin beds of limestone. The shale gives rise to the Summit soils. The Pettis silt loam is derived partly from the interbedded limestone and shale of this formation.

The Bethany Falls limestone occurs in the northwestern part of the county, forming a distinct but ragged escarpment along the streams. It gives rise to the Crawford and Pettis soils, the former being derived exclusively from limestone, while the latter contains considerable material derived from shale.

The Warrensburg sandstone marks the western boundary of the central lowland belt of the county. It extends in a north and south direction through Fayetteville, Warrensburg, and Postoak, occupying an old channel from 1 mile to 2 miles wide carved through strata of the Cherokee and Henrietta formations, which is now filled with more or less massive sandstone and shale, possibly Pleasanton. The sandstone is quarried north of the city of Warrensburg. Drillings show 75 feet of gray sandstone. This formation, as well as the interbedded sandstones of other formations in the county, gives rise to the Boone soils.

The limestone beds of the region are uniform in character and chert free. They are bluish gray in fresh fractures, but become dark brownish drab on exposure. Many are only a few feet thick, although some are 20 to 25 feet or more. All are more resistant to weathering than the shales.

The shales vary in color from grayish yellow to drab and black. The black shales are usually hard and compact, almost as hard as slate.

The sandstones are medium grained and not very firmly cemented. In some cases, however, they withstand erosion almost as well as limestone. They are commonly yellowish and gray.

Sixteen soil types, representing 10 series, are mapped in Johnson County. The residual or upland soils comprise about 85 per cent of the total area of the county and include the Summit, Pettis, Crawford, Boone, Bates, Oswego, and Cherokee series. The soil material in some places has a depth of 30 feet or more, the greatest thickness occurring where the softer shales underlie the surface. The Summit, Oswego, and Cherokee soils are residual largely from shale, which is calcareous in case of much of the Summit; the Crawford and Pettis soils are residual from limestone, with some shale material in the case of the Pettis; the Boone soils are residual from sandstone and shale, and the Bates soils from shale and interbedded sandstone and limestone.

The lowland or alluvial soils are grouped into three series, the Osage (first-bottom) soils and the Chariton and Robertsville (second-bottom or terrace) soils. In subsequent chapters the different soil types are described in detail.

The following table gives the names and the actual and relative extent of the various soil types mapped in Johnson County:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Summit silt loam.....	146,240	27.5	Osage silty clay loam.....	4,672	0.9
Boone silt loam.....	142,848	26.9	Summit silty clay loam.....	3,648	.7
Osage silt loam.....	65,088	12.2	Cherokee silt loam.....	1,920	.4
Bates silt loam.....	58,816	11.1	Osage clay.....	1,792	.3
Oswego silt loam.....	35,328	6.6	Robertsville silt loam.....	1,728	.3
Pettis silt loam.....	29,312	5.5	Boone gravelly loam.....	1,152	.2
Crawford silt loam.....	23,680	4.4	Crawford stony loam.....	896	.2
Boone fine sandy loam.....	9,408	1.8			
Chariton silt loam.....	5,312	1.0	Total.....	531,840	.....

SUMMIT SERIES.

The Summit soils are dark gray to black in color to a depth of 8 to 12 inches. The subsurface material is brown to light brown, slightly heavier than the soil, and friable in structure. The upper subsoil, into which the subsurface layer passes gradually, is a plastic silty clay to clay, dark drab in color, with spots of yellowish brown. The lower subsoil is predominantly grayish yellow or yellow, with abundant gray mottlings. These soils are residual in origin and are derived from shales and limestones. The drainage is good and the topography smooth to undulating. In Johnson County two types of this series are recognized, the silt loam and the silty clay loam.

SUMMIT SILT LOAM.

The surface soil of the Summit silt loam, where typically developed, consists of a black silt loam to a depth of 15 inches, below which it grades into a silty clay loam of a somewhat lighter color. The subsoil, beginning at a depth of 24 to 26 inches, is a heavy clay of dark-drab color. At a depth of about 30 inches it usually shows mottling of yellow and gray. The line of demarcation between the surface and subsurface soil is rather indistinct, but the gradation into the clay subsoil is usually sharp. There are some minor variations in this type. In some places the surface soil is light gray in color and in others a grayish-brown layer occurs at a depth of 10 to 12 inches. Here and there the material is mottled yellow and gray at a depth of 20 inches; the mottling is very pronounced in the lower subsoil.

To the south of Holden a heavy to impervious subsoil is encountered in this type below about 25 inches. As mapped in the vicinity of Cornelia and Leeton, the type represents an extreme variation toward the Oswego silt loam, differing from the typical Summit silt loam in being somewhat lighter colored and having a rather impervious subsoil.

Small eroded areas of the Summit silt loam occur in a few places in the northwestern part of the county. Here the soil consists of a light-gray silty clay loam, grading abruptly into a gray to grayish-drab, impervious clay. Such areas are too small in extent to be shown on the map. They are locally spoken of as "deer licks," and support little or no vegetation.

Small, narrow strips of a stony variation of this type are encountered along steep, stony slopes near streams and on the sides of ridges. These areas are indicated on the map by stone symbols. Limestone outcrops and fragments are abundant. The soil material is a black to grayish-black silty clay loam to clay, grading into a yellowish-brown or gray, plastic clay at a depth of about 10 inches. Bedrock is usually encountered in these areas within the 3-foot section. The stony areas are in pasture. They are small and of little economic importance. Pasture on them is generally fair in seasons of ample rainfall, but the soil material, being heavy and not very deep, quickly dries out. Oak, hickory, elm, and black walnut constitute the forest growth.

This is the most important and most extensively developed soil type in the county, covering an area of 228.5 square miles. It occurs mainly in the vicinity of Kingsville and in the northern half of the county.

In general the Summit silt loam occupies the smoother areas of the county. It occurs on the tops of ridges and on lower level stretches

surrounded by escarpments of limestone outcrop. It is generally sufficiently rolling to have good surface drainage, although the character of the subsoil does not permit a maximum absorption of water. It is locally referred to as "black limestone land," probably because of the frequent outcrops of thin limestone beds along streams.

Practically all the type is under cultivation. It was originally prairie and was very rich in organic matter when first cultivated, owing to the heavy growth of prairie grasses that had covered it.

The raising of live stock, principally beef cattle and hogs, in conjunction with grain growing, constitutes the main industry on the type. Corn, wheat, oats, clover, and grasses are the principal crops. This is an excellent soil for grazing, as bluegrass, timothy, and other grasses thrive. Corn yields of 45 bushels per acre are reported for 1914. In more favorable seasons yields of 75 to 80 bushels per acre are frequently obtained. Some dairying is practiced, and this industry is receiving increasing attention.

Owing to the plastic character of the subsoil, this type is rather cold and wet in the spring, and on this account the seeding of crops is frequently delayed. While most of the type is in fair physical condition, continuous cropping without adequate provision for the maintenance of the organic matter has brought about a condition of poor tilth and a decrease in crop yields on many farms.

Land of this type sells for \$65 to \$150 an acre, depending on location and improvements. Most of it is valued at \$75 to \$90 an acre.

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

Mechanical analyses of Summit 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.	<i>Per cent.</i>
343507.....	Soil.....	0.4	1.3	0.9	1.0	2.7	79.2	14.6
343508.....	Subsoil.....	.0	.4	.1	.7	2.2	56.0	40.4

SUMMIT SILTY CLAY LOAM.

In its typical development the surface soil of the Summit silty clay loam is a dark-gray to blackish silty clay loam, black when wet. This grades at about 15 to 18 inches into a drab to grayish-brown clay, mottled with yellow and gray in the lower part. In many places the type occurs in narrow strips at the foot of elevations, sometimes extending considerable distances up the slopes. Usually such areas are poorly drained, and the soil approaches a clay loam in texture, frequently being referred to as "gumbo" land. Such areas are found in many parts of the county, and are indicated

on the soil map where large enough to be shown satisfactorily. The formation of the type in such places is due to the washing in of clay and silt particles from the land above. A number of small areas of black, broyn, or even gray clay are included with this type as mapped. They occur in narrow strips along the streams where limestone outcrops. The subsoil is usually a gray clay with abundant limestone nodules. The areas are so small that they are of no agricultural importance.

The Summit silty clay loam has a small total area, covering 5.7 square miles. The most extensive areas occur in the southwestern corner of the county.

This soil is usually very productive and when in good moisture condition it is friable and easily cultivated. When plowed while wet it puddles and its physical condition is greatly impaired until granulation is restored by alternate freezing and thawing, or by becoming wet and then drying. Owing to its large clay content, cracks frequently form in areas of this type, which permit the loss of moisture from the surface and subsurface soil and which in forming sometimes tear the roots of growing crops.

Corn does particularly well on this type, yields of 75 bushels per acre being obtained in favorable seasons. Clover and grasses also do well where the soil is well drained.

In some places along the slopes the soil contains lime concretions, the shales from which it is derived being closely associated with limestones. Clover does well in such areas.

As the areas of this type are small, it is held in connection with other soils.

PETTIS SERIES.

The soils of the Pettis series are brown to dark brown in color. At a depth ranging from 6 to 12 inches they grade into a brown to yellowish-brown, friable subsoil, slightly heavier than the soil. The color, texture, and structure continue practically uniform throughout the 3-foot section, though faint grayish mottlings may appear below 30 inches. These soils are residual from shales and the topography is smooth to undulating. One type, the Pettis silt loam, is recognized in Johnson County.

PETTIS SILT LOAM.

The Pettis silt loam typically is a very dark brown to black, mellow silt loam to a depth of about 18 inches, below which it grades into a slightly heavier silt loam of dark reddish brown color. At 25 inches the subsoil is a brown silt loam to silty clay loam, which continues to a depth of 36 inches, becoming slightly heavier in the lower part of the 3-foot section. In places in the vicinity of Fayetteville and Columbus the soil is lighter in color, being brown to dark

brown in the surface section and light brown below. In some places mottlings of yellow and gray appear in the substratum.

The Pettis silt loam has its most extensive development in the northwestern and north-central parts of the county. It grades into the Crawford and Boone soils on the one hand and into the Summit series on the other. It occupies the level tops of ridges, the topography being more rolling than that of the Summit silt loam. This type differs from the Summit silt loam in having a much more friable subsoil and a lighter color. The soil mapped in the survey of Jackson County as a brown phase of the Summit silt loam is identical with the Pettis silt loam in this county. Erosion is becoming active in places on the slopes, making the growing of winter cover crops advisable. The type is spoken of locally as "mulatto land." It is held in very high esteem by farmers, and is considered one of the most productive soils in the county. Its deep, porous nature makes it especially drought resistant, and it is easily maintained in a condition of good tilth.

The tendency on this type is toward a diversified system of grain farming in conjunction with the raising of live stock, with beef cattle and hogs as the main source of income. Corn, wheat, oats, clover, and grasses are grown extensively and do particularly well. Alfalfa also does well. This is an excellent fruit soil, although the fruit industry is not very important and there are few commercial orchards. Maximum yields of 75 bushels of corn per acre are obtained in favorable seasons. In 1914 the estimated average yield of corn was 45 bushels per acre and of wheat 25 bushels. The type is well suited to clover, and the extensive growing of this crop is largely responsible for its high state of productiveness.

Land of this type in the vicinity of towns sells for \$125 an acre. Much of it, however, is somewhat remote from markets and can be bought for \$75 to \$95 an acre.

The results of mechanical analyses of samples of the soil and subsoil of the Pettis silt loam are given in the following table:

Mechanical analyses of Pettis 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.	<i>Per cent.</i>
343505.....	Soil.....	0.1	0.4	0.4	0.6	2.2	75.0	21.3
343506.....	Subsoil.....	.2	.9	.4	.9	2.0	69.0	26.6

CRAWFORD SERIES.

The Crawford series comprises residual limestone soils of the prairie regions, with dark-brown to reddish-brown surface soils and

reddish-brown to red subsoils. They are derived from limestones, often with more or less material from shales. These soils occupy undulating or rolling country and some local areas of rough, broken topography. They are generally well drained. In this county only two members of the series are recognized, the Crawford silt loam and stony loam.

CRAWFORD SILT LOAM.

The Crawford silt loam consists of a red or reddish-brown to brown silt loam, underlain at depths of 12 to 18 inches by a reddish-brown silty clay loam. At a depth of about 27 inches the subsoil grades into a red, crumbly clay, which extends to a depth of 36 inches or more. In places along slopes bedrock is encountered within the 3-foot section.

This soil is found in practically all parts of the county, but there are no extensive single areas. It occurs on the tops of ridges underlain by limestones. In some places limestone ledges 20 to 30 feet high border the type and render much of it unfit for agricultural use, except for pasture.

Where it occurs on the tops of broad, level ridges the soil is deep and very productive. Where the Crawford soil occurs on slopes the Summit soil almost invariably occupies the tops of the ridges. In such cases the dark-colored Summit soil extends over the red subsoil of the Crawford. In flat or smooth areas, as in the western part of the county, it is less affected by the dark color of the Summit.

The Crawford silt loam, locally referred to as "red soil," is regarded by farmers as the strongest soil in the county. Like the Pettis silt loam it is a good clover soil. Estimated yields of 2½ tons of clover hay per acre are reported for normal seasons. Alfalfa does better on this type and on the Pettis silt loam than on the other upland soils. Corn, small grains, and fruit produce heavily.

The topography is rolling, although there are some comparatively smooth areas. In general, this type has a more uneven surface than the Summit and Pettis soils. Most of it occurs at a higher level than the associated Summit soils. It is drained by numerous small streams, which are frequently bordered by ledges of limestone, giving rise to small, stony areas.

The greater part of the Crawford silt loam originally was forested, the principal tree growth consisting of walnut, elm, ash, cherry, and oak. All of it is now under cultivation. It is a well-drained soil and produces good yields of all the crops grown in the county. Its porous nature renders it more drought resistant and more easily cultivated than the types with heavy, plastic subsoils.

Erosion is active in places on the steep slopes. This can be largely prevented by the incorporation of organic matter in the soil, deep plowing, and the growing of winter cover crops.

CRAWFORD STONY LOAM.

The surface soil of the Crawford stony loam is a dark reddish brown loam, usually extending to a depth of about 6 inches. The subsoil is a reddish-brown to red clay extending to a depth of 36 inches or more or to the underlying limestone. Limestone fragments are abundant.

The type as mapped includes an area of Boone stony loam in the vicinity of Dunksburg along Blackwater River, which is not shown on the map because of its small extent. The soil of the Boone stony loam is a yellowish-brown fine sandy loam to loam. Fragments of sandstone are scattered over the surface. Also in some places small areas of Summit stony loam are associated with the Crawford stony loam, or small areas of the Crawford stony loam are associated with larger areas of the Summit stony loam. These minor areas are not separated, on account of their small extent.

The Crawford stony loam occurs along steep slopes and along the outcrop of the Bethany Falls limestone in the western part of the county and that of the Henrietta limestone through the eastern part of the county.

Most of the type is unfit for cultivation, but much of it supports a good growth of bluegrass and makes good pasture land. The tree growth consists mainly of scrub oak and hickory.

BOONE SERIES.

The Boone series includes light-brown to gray soils containing a low percentage of organic matter, underlain by pale-yellowish to slightly reddish yellow, porous subsoils. A bedrock substratum is frequently encountered at a shallow depth. The soils of this series are of residual origin, being derived from sandstones and shales, principally of Carboniferous age. The topography is rolling to steeply sloping and the soils are usually forested. The Boone soils are closely associated with the Bates, but differ from them in containing less organic matter and in being consequently lighter in color. In this county three types of this series are mapped—the Boone silt loam, fine sandy loam, and gravelly loam.

BOONE SILT LOAM.

The Boone silt loam consists of a grayish-brown silt loam, underlain at a depth of 5 or 6 inches by a layer of gray silt loam. At 15 to 18 inches a yellowish-gray to grayish-brown silty clay loam is encountered, and this grades at about 25 inches into a friable clay of grayish-brown color mottled below with yellow. This soil is quite variable in texture, especially where it grades into the fine sandy loam. In places along the slopes small areas of loam are encountered.

Areas in which the Boone silt loam has been severely eroded occur in various places, mainly a short distance south of the railway be-

tween Montserrat and Knobnoster. A small area lies just south of the southward bend of Blackwater River, $1\frac{1}{2}$ miles northeast of Valley City. The soil material in these areas is a yellowish-gray silt loam to a depth of 4 inches, where it grades into a yellow to mottled yellow, gray, and brown silty clay loam to clay. These areas are very thoroughly dissected by stream erosion, which mainly accounts for the thin layer of soil. They are of lower agricultural value than the typical Boone silt loam. In places many shale fragments are present.

In the northwestern part of the county, on the slopes of creeks flowing through the Pettis and Crawford soils, there are a number of small areas of a soil somewhat unlike the Boone silt loam included with this type. The soil is a grayish-brown silt loam, underlain by a light-brown silty clay loam, grading into a heavy clay at about 25 inches. This soil is derived from limestone and shale, and outcrops of limestone are frequent. It is subject to erosion on account of its sloping topography. Most of the land included in this variation is in cultivation, and it is similar to the typical soil in crop value.

The Boone silt loam has a wide distribution, occurring along all the streams of the county. It is extensively developed from the vicinity of Warrensburg to Knobnoster and Henrietta. The topography is rolling to hilly along some of the streams, notably along Clear Creek.

All of this type was originally covered with a forest growth of elm, hickory, oak, and walnut. It is estimated that about 85 per cent of the type is in cultivation, the remainder being in forest and pasture.

While the type is of lower agricultural value than the soils of the Summit, Pettis, and Crawford series, it can easily be improved. It is naturally low in organic matter and is greatly benefited by the plowing under of stable manure or leguminous crops, such as clover, soy beans, and cowpeas, and by applications of ground limestone. The incorporation of green manures, in addition to increasing the productiveness of the soil, tends to prevent erosion, which is becoming serious on some farms. Land of the Boone silt loam sells for \$45 to \$75 an acre.

Results of mechanical analyses of samples of the soil and subsoil are given in the following table:

Mechanical analyses of Boone 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.	<i>Per cent.</i>
343521.....	Soil.....	0.0	0.7	0.4	1.8	8.0	68.2	20.9
343522.....	Subsoil.....	.1	.4	.3	1.5	5.1	60.6	31.8

BOONE FINE SANDY LOAM.

Typically the Boone fine sandy loam is a yellowish-gray to yellowish-brown fine sandy loam, underlain at about 18 inches by a loam stratum, below which the soil usually is a yellowish-brown sandy clay loam, becoming slightly heavier with depth and having a reddish shade in places.

This soil has its most extensive development in a belt about 3 miles wide extending from Fayetteville to Postoak. It occurs along the slopes of streams running through the Warrensburg sandstone area. Small areas about 10 to 30 acres in extent are mapped in different parts of the county. Usually such areas occupy high elevations surrounded by soils of the Summit series, the elevations being due to the more resistant character of the sandstones as compared with the shales. In places erosion is quite active.

Most of this soil is in cultivation. It is deficient in organic matter, and less productive than the heavier soils. It is warm and porous, however, and with liberal applications of manure, or with crop rotations including leguminous crops, produces good yields of small fruits and fair yields of corn and wheat.

Included with the Boone fine sandy loam are a number of small areas of Bates fine sandy loam. They differ from the Boone soil in their darker color. The soil is a dark-gray to black fine sandy loam in the surface 12 to 15 inches, underlain by a brownish sandy loam to sandy clay loam, mottled below 25 inches with yellow and red. It has a rolling topography, and occurs in small areas in the southern part of the county, the largest body comprising about 125 acres and lying in the southeast corner of section 31, about 3 miles north of Chilhowee. Another area occurs in the southern part of section 29, 3 miles southeast of Chilhowee, and two others in sections 19 and 4, 1 mile east and 4 miles northwest, respectively, of Chilhowee. This soil has a slightly higher agricultural value than the Boone fine sandy loam. It is a warm soil and very productive of truck crops. Owing to the remoteness from markets, however, it is used for the production of grain crops, which do well where the soil is sufficiently supplied with organic matter. This soil is very limited in extent and of little importance.

BOONE GRAVELLY LOAM.

The surface soil of the Boone gravelly loam is a yellowish-gray silt loam to silty clay loam, carrying about 10 to 20 per cent of gravel derived from shales. It is underlain by a clay loam to clay, generally of a grayish to mottled yellow and gray color.

This type occurs principally in the section to the south of Montserrat, occupying steep slopes along the creeks and ravines. It supports a good growth of grass. The trees consist mainly of hickory and scrub oak. Little of the type can be cultivated, on account of

its rough topography. It is of practically no agricultural importance.

BATES SERIES.

The soils of the Bates series are dark gray. The subsoils are yellowish or mottled red and yellowish or buff in the upper part and mottled yellow and red in the lower part. The series is of residual origin, and is derived from sandstone and shale with interbedded limestones. The soils of this series are distinguished from those of the associated Oswego series by their pervious subsoils and from the Boone series by the darker color of the surface soils. In Johnson County the series is represented by a single type, the Bates silt loam.

BATES SILT LOAM.

The Bates silt loam is typically a dark grayish brown to black silt loam, grading at about 15 inches into a brown to grayish-brown silty clay loam mottled with yellow. The subsoil below about 25 inches is a brown to yellowish-brown silty clay loam or clay loam, with yellow and red spots in the lower part of the 3-foot section.

The type has its most extensive distribution in the southern part of the county in the vicinity of Leeton and Chilhowee. Its topography, except along the slopes of creeks, is smooth to rolling. It is an important agricultural soil and ranks as one of the most productive in the county when properly managed. The character of the subsoil is such that the type is especially drought resistant, and the material is sufficiently porous to permit an extensive root development. Excepting the Pettis and Crawford silt loams, this type has the best physical structure of any residual soil in the county. Its organic-matter content on many farms is rather low, however, owing to the continuous production of grain crops without adequate provision for the supplying of manure to the land.

All this type is under cultivation, corn, wheat, and hay being the principal crops. Clover does well, though not extensively grown. Grasses also do well. Bluegrass spreads rapidly over pasture land. In some cases the land is left in pasture for a period of two or three years.

Land of this type sells for \$65 to \$100 an acre, depending on location and improvements. Most of it is valued at \$65 to \$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 Bates 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.	<i>Per cent.</i>
343501.....	Soil.....	0.3	1.4	0.8	1.6	3.8	72.3	19.7
343502.....	Subsoil.....	.2	1.2	.6	2.2	5.4	70.9	19.5

OSWEGO SERIES.

The soils of the Oswego series are dark brown to a depth ranging to about 12 inches. The soil grades into a gray subsurface layer, slightly heavier than the soil, and this in turn, at depths ranging from 15 to 20 inches, passes rather abruptly into a tough, plastic silty clay to clay layer, dark drab in color, mottled with dark reddish brown. At about 30 inches there is a lighter colored and lighter textured, friable silty layer, usually yellow with gray mottlings. The soils are residual in origin and are derived from shales. The topography is smooth. In Johnson County this series is represented by one type, the Oswego silt loam.

OSWEGO SILT LOAM.

The soil of the Oswego silt loam is a dark-gray to grayish-brown silt loam, which becomes somewhat lighter in color at a depth of about 10 inches. At about 15 inches a chocolate-brown to drab-colored, heavy silty clay loam is encountered, and at 18 to 27 inches the subsoil is a brownish to drab, impervious, heavy clay which becomes mottled yellow, gray, and brown in color, more silty in texture, and more friable in structure in the lower 6 inches of the 3-foot section. When dry the surface soil is light gray. The soil is very deficient in organic matter and of low moisture-holding capacity.

Small areas of this type in the vicinity of Cornelia and Leeton resemble the Summit silt loam in physical characteristics, the subsoil being more pervious and the surface soil darker in color than the typical Oswego silt loam. Another small area which is not typical occurs about 6 miles south of Knobnoster on a slope along Muddy Creek. In this area the soil is largely colluvial material from the Oswego silt loam. The surface soil is brown to brownish gray in color and the subsoil is more pervious than typical. This variation has a slightly higher agricultural value than the main type.

The Oswego silt loam has an extensive distribution in the extreme southeastern part of the county. The topography varies from flat to gently undulating. Subdrainage is generally deficient, owing to the impervious character of the subsoil, which in places approaches the structure of hardpan, and crops suffer from drought. Much of the type is locally called "hardpan land."

The type is devoted mainly to wheat, corn, and grasses. Fair yields of corn are obtained, depending largely upon the seasonal conditions. It is a good soil, but clover and alfalfa do not do well. Cowpeas and soy beans are grown more extensively than formerly. Applications of ground limestone at the rate of 2,000 pounds or more per acre and of phosphatic fertilizers also are beneficial. Sweet clover has been tried with varying results; where limestone is applied sweet clover does well.

Land of this type sells for \$65 to \$95 an acre, depending upon location and improvements.

CHEROKEE SERIES.

The soils of the Cherokee series are brown to gray, and of floury structure. The subsurface material is nearly white and slightly heavier in texture than the surface soil. The upper subsoil, which begins abruptly at 12 to 15 inches, is a tough, waxy clay to silty clay, dark drab in color, with mottlings of reddish brown or yellowish brown. The deeper subsoil is lighter in color and friable. These soils are residual from shales and have a level or very gently rolling topography. The silt loam is the only member of the Cherokee series mapped in Johnson County.

CHEROKEE SILT LOAM.

The Cherokee silt loam is light brown to brown in color with gray subsurface material. The subsoil, beginning abruptly at 12 to 20 inches, is a heavy, plastic clay, dark drab in color with yellowish-brown to reddish-brown mottlings. Below 24 to 30 inches the material is often lighter in both color and texture and more friable in structure.

The Cherokee silt loam is inextensive, occurring in the southeastern part of the county along Muddy Creek and other small streams southeast of Knobnoster. The topography is smooth. The soil is poorly drained, owing to its subsoil structure and its topographic position. Most of it is in pasture. Its agricultural value is rather low.

Following are the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Cherokee 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.	<i>Per cent.</i>
343513.....	Soil.....	0.3	1.7	0.4	0.6	4.2	70.8	21.5
343514.....	Subsoil.....	.0	.4	.2	.4	3.5	80.0	15.2

OSAGE SERIES.

The Osage series consists of dark-gray to almost black soils composed of alluvial wash from the sandstone and shale soils of the prairie regions. Three types, the Osage silt loam, silty clay loam, and clay, are recognized in Johnson County.

OSAGE SILT LOAM.

The Osage silt loam is variable in color and texture. Predominantly it is a dark-gray to brownish-black, mellow silt loam to a depth

of about 16 inches, below which the color is lighter gray to grayish drab. At about 20 inches the material is a silty clay loam, which grades below into a drab clay.

Along many small streams of the county this type has a surface layer of colluvial material from the Boone silt loam. South of Warrensburg, along small tributaries of Postoak Creek, the soil is a fine sandy loam of a brown color, becoming a light-brown to grayish-brown loam in the lower stratum. This is really a development of the Osage fine sandy loam, which, on account of its small extent, is not separated. Most of the fine sandy loam material represents a colluvial deposit derived from the Boone fine sandy loam of the upland.

Along Blackwater River, particularly north of Warrensburg, the soil below 12 inches is much heavier than usual, being a heavy silt loam. The subsoil of such areas usually is a drab-colored, tenacious clay to clay loam in the lower part of the 3-foot section.

North of Knobnoster, along the banks of Blackwater River, occur small forested stretches which have a lighter color than the typical soil, being a dark-brown silt loam in the surface section and grading into a grayish-brown silty clay loam below.

The material of the Osage silt loam consists of alluvium derived from the residual soils of the uplands. In areas of the Crawford and Boone soils the border of the bottom is usually marked by a sharp escarpment, whereas in areas of the Summit soils the rise from the valley to the upland is usually gradual.

The Osage silt loam occupies stream bottoms varying in width from a few rods to a mile or more. The topography is smooth.

This soil is much more easily maintained in a productive condition than the upland types because of the deposition of material rich in plant food by the occasional overflows. The porous nature of the soil and subsoil favors good drainage and the soil is ready for cultivation soon after overflows. It is a better drained soil than either the Osage silty clay loam or clay.

The agricultural value of this type, as well as that of the other first-bottom soils, has been greatly enhanced in recent years by the construction of an extensive system of drainage ditches. Corn, alfalfa, clover, and wheat do well and are grown extensively.

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

Mechanical analyses of Osage 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.	<i>Per cent.</i>
343523.....	Soil.....	0.0	0.4	0.2	1.0	4.6	70.5	23.3
343524.....	Subsoil.....	.0	.2	.2	.9	4.2	70.6	23.9

OSAGE SILTY CLAY LOAM.

The surface soil of the Osage silty clay loam is a dark-gray to almost black silty clay loam, underlain at 18 to 20 inches by a drab to black clay loam, which changes into a drab, heavy, plastic clay in the lower part of the 3-foot section. Brown and gray mottlings sometimes appear in the lower subsoil.

The type occurs in close association with the Osage silt loam. It is a first-bottom soil derived from the upland soils of the Summit, Bates, Oswego, Crawford, Pettis, and Boone series. It has its most extensive distribution along Big Creek in the southwestern part of the county, although other important areas are found along Blackwater River and other streams.

The type is generally best developed near the outer margin of the bottoms. Although its position is lower than that of the silt loam, the difference in elevation is not marked by terraces; the slope to the silt loam is almost imperceptible.

The type is subject to overflow from the streams along which it occurs. It is not so well drained as the silt loam, and on account of its heavier texture is not so easily worked. If plowed when too wet the soil clods and puddles. It is greatly benefited by fall plowing and the incorporation of large quantities of organic matter. Corn and wheat are the principal crops grown, and good yields of both are obtained.

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

Mechanical analyses of Osage 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.	<i>Per cent.</i>
343519.....	Soil.....	0.0	0.1	0.1	1.6	2.9	58.6	36.6
343520.....	Subsoil.....	.1	.4	.3	.5	2.2	65.9	30.6

OSAGE CLAY.

The Osage clay consists of a black, heavy, plastic clay or clay loam, grading at about 12 inches into a bluish-black to drab-colored plastic clay, which continues throughout the 3-foot section. It has been formed by deposition from overflows and backwater, the currents of which carry only the clay and finer silt particles.

This type is inextensive and occupies depressed areas in the bottoms of Big Creek and Blackwater River, which usually occur away from the channels of the streams at the foot of the upland. It lies at a lower level than any of the other bottom soils, being slightly lower than the silty clay loam, with which it is associated, and it is very poorly drained.

About 50 per cent of this soil is cultivated. Some of it is covered with wild grasses and is used for pasture. Corn is the principal crop grown and in favorable years yields of 75 bushels per acre are obtained. Frequently, however, the crop is injured by floods. The soil is greatly improved by the plowing under of organic matter.

CHARITON SERIES.

The surface soils of the Chariton series are dark in color, ranging from dark gray to black. The subsurface layer, encountered at depths of 10 to 15 inches, is usually lighter in color than the surface material. The change from the subsurface layer to the subsoil is abrupt and the latter consists of a dark-drab, heavy, plastic silty clay with yellowish-brown spots. The lower subsoil is usually lighter in color and in texture than the upper subsoil. These soils are derived from old alluvial deposits occurring as terraces, and the topography is generally flat.

CHARITON SILT LOAM.

Typically the Chariton silt loam is a dark-gray to black silt loam, underlain at about 12 inches by a grayish-brown silt loam to silty clay loam, which grades at a depth of about 18 inches into a dark-grayish or brownish-drab mottled with brown, compact silty clay loam or clay.

In places the soil is a black, mellow silt loam, grading at a depth of about 18 inches into a grayish-brown to drab silty clay loam or clay, which becomes slightly heavier and darker colored at a depth of about 25 inches.

The Chariton silt loam is a terrace or second-bottom soil occurring along the various creeks of the county, and occupying former flood plains of the streams. The largest area of the type occurs along Blackwater River, in the extreme northeastern part of the county. Many smaller areas occur in other sections. The topography is flat. The type has an elevation generally of 15 to 20 feet above the level of the first bottom, and only a small part of it is subject to overflow. In some places, however, the difference in elevation is not over 5 or 6 feet as shown at the margin of the terrace.

This soil is very productive, and more drought resistant than the upland types. Corn, wheat, and clover are the principal crops grown. Clover and alfalfa do particularly well, the former frequently yielding 2 tons of hay per acre. With proper management, including the frequent working of the surface soil in order to conserve the moisture, this type is easily maintained in a high state of productiveness.

One small area of the Chariton silty clay loam, comprising about 120 acres, occurs 2 miles northeast of Montserrat on the west side

of Clear Creek. On account of the small size, it is included with the silt loam. As in the case of the silt loam the material is derived through wash from the upland soils. The silty clay loam occupies a former flood plain of the creek. It has a slightly lower level than the silt loam. The surface 12 or 15 inches of the area is a black silty clay loam. This grades into a dark grayish black to drab, heavy, plastic clay. Below 30 inches the subsoil is a drab clay, frequently containing yellow mottlings. The soil is very productive. Corn, wheat, and clover do well.

The results of mechanical analyses of samples of the soil and subsoil of the Chariton silt loam are given in the following table:

Mechanical analyses of Chariton 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.	<i>Per cent.</i>
343517.....	Soil.....	0.0	0.4	0.4	0.9	5.2	67.4	25.5
343518.....	Subsoil.....	.1	.4	.2	.5	3.0	63.6	31.8

ROBERTSVILLE SERIES.

The soils of the Robertsville series are gray to grayish brown and prevailing silty. The subsoils typically consist of a gray to white, compact layer of silt loam to silty clay loam overlying a lower subsoil stratum of compact, impervious, plastic clay of a gray to brownish color, with some faint mottlings of reddish brown. Black oxide of iron concretions are common. The soils represent old stream alluvium, occupying terraces and abandoned stream valleys no longer subject to overflow. Only one member of this series, the Robertsville silt loam, is recognized in Johnson County.

ROBERTSVILLE SILT LOAM.

The soil of the Robertsville silt loam is an ashy-gray silt loam, grading at a depth of about 15 inches into a grayish-brown, compact silty clay loam. At about 25 inches a brownish, heavy, plastic clay, containing mottlings of gray and yellow, is encountered. Black oxide of iron concretions are usually present in the subsurface stratum.

This is a terrace or second-bottom soil occurring along the creeks of the county. It usually occupies a lower level than the Chariton soils. Parts of it are subject to occasional overflow. It is derived from wash from the upland soils and, like the associated Chariton series, represents abandoned flood plains.

The topography is flat, except where there are slight undulations that represent old stream or overflow channels. Most of the type is poorly drained, and the establishment of artificial drainage is difficult.

Wheat and grass do fairly well on this soil in favorable seasons. Alsike clover does better than red clover. White clover does well where the land is left in pasture. The soil is benefited by applications of ground limestone and the addition of organic matter.

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

Mechanical analyses of Robertsville 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.	<i>Per cent.</i>
343511.....	Soil.....	0.1	1.1	0.4	1.3	4.6	71.2	21.0
343512.....	Subsoil.....	.2	1.9	.7	1.6	3.4	64.4	27.4

SUMMARY.

Johnson County lies in the residual prairie division of the Great Plains region. Its area is 831 square miles, or 531,840 acres. It is one of the leading agricultural counties of Missouri. The county comprises two main physiographic divisions, the upland and the lowland. Topographically, it is rather more rolling than undulating or level.

The transportation facilities are good. Roads are well graded. The bridges usually are of steel and the culverts of concrete.

The population is reported by the census of 1910 as 26,297. The majority of the inhabitants are engaged in farming.

The system of agriculture followed consists largely of grain farming, in conjunction with the feeding and raising of live stock, principally beef cattle and hogs. The dairy industry is receiving increasing attention in some parts of the county. Farm practices in general are good. Methods of improving the soils include the incorporation of organic matter in the form of manure or leguminous crops plowed under, the application of phosphatic fertilizers and ground limestone, and the maintenance of a surface mulch in order to conserve moisture.

The soils of Johnson County are divided into two broad groups, the upland soils and the lowland soils.

The upland soils are residual from the immediately underlying rocks, consisting of alternating beds of shale, limestone, and sandstone. The residual soils comprise about nine-tenths of the total area of the county, and are classed with seven soil series, the Summit, Pettis, Crawford, Boone, Bates, Oswego, and Cherokee.

The Summit and Pettis soils, derived from shale and limestone, represent the black prairie soils. They include the best land in the county, are very productive, and are suited to all the staple crops, of which corn, wheat, and grass are the most important.

The Crawford soils comprise the red limestone land, and are characterized by their reddish color and mellow structure. They are naturally productive, and well adapted to wheat, clover, and fruit.

Shale and sandstone give rise to the Boone and Bates series. These soils are used for the production of staple crops, but require careful farming in order to produce large yields.

The Oswego and Cherokee soils, derived from shale, are characterized by light-colored surface soils and compact subsoils. They are somewhat inferior agriculturally to the black prairie soils.

The lowland or alluvial soils are composed of alluvium from the uplands. They are grouped in three series, the Osage (first-bottom) soils and the Chariton and Robertsville (second-bottom) soils. The first-bottom soils are generally subject to overflow, but comprise some of the most productive land in the county. They are used largely for corn and grass. The second-bottom soils of the Chariton series are characteristically black as distinguished from the gray second-bottom soils included in the Robertsville series. The black soils are above ordinary high water and are highly productive. The gray soils are mostly above overflow. It requires more careful methods of management to maintain them in a productive state.



[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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