

SOIL SURVEY OF BATES COUNTY, MISSOURI.

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DESCRIPTION OF THE AREA.

Bates County is situated midway of the western boundary of the State of Missouri. It is bounded on the north by Cass County, on the east by Henry and St. Clair counties, on the south by Vernon County, and on the west by Linn and Miami counties, Kansas. Its southern boundary lies about 4 miles north of parallel 38° north latitude, and meridian 94° west from Greenwich passes about 4 miles

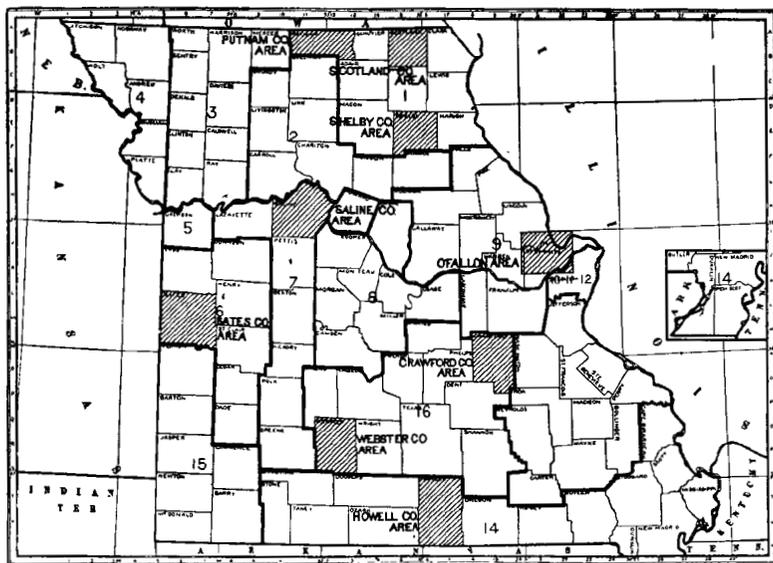


FIG. 31.—Sketch map showing location of the Bates County area, Missouri.

east of the eastern boundary. The county has a length north and south of about 30 miles and a width approximately the same, and comprises 554,240 acres, or 866 square miles.

Topographically Bates County consists of three terraces, each of which is more or less dissected by valleys. The lowest terrace is in the southeastern part of the county and the highest in the northwestern part. The average elevation of the lowest is about 650 to 700 feet, the middle one about 800 to 850 feet, and the upper one about 1,000 feet above sea level. The highest one has the smallest extent and the middle one the greatest. In fact, by far the larger part of the county is included in the latter. Its eastern boundary runs from

Rich Hill nearly eastward to a point $2\frac{1}{2}$ miles south of Pleasant Gap, thence northeastward to the offset in the county line at the southwestern corner of Henry County. Its western boundary runs from the Kansas line near Amsterdam northward to Merwin, thence about eastward to near Adrian, thence northwestward to the northern boundary of the county, about 6 miles east of the northwest corner. At its eastern boundary this terrace drops rather abruptly about 150 feet to the lowest terrace, and its western boundary is the abrupt rise of about 150 feet to the highest terrace. The eastern border of this middle terrace is much dissected by deep valleys of streams that flow from it out into the lower terrace. The cut is much deeper into it than into the lower terrace, because it is so much higher than the latter. Westward and northwestward from the eastern boundary the valleys are more and more shallow, until along the northwestern border of the terrace there is a belt that is barely cut by valleys at all. In fact, there are considerable areas along it that are not well drained.

Only the northwestern part of the lower terrace lies in Bates County, the rest of it lying to the eastward. The whole of this area therefore is smooth. Its valleys are very shallow, even that of the Osage River; it is a gently undulating plain. Only the eastern border of the third terrace lies in this county. The most of it is a high dissected plateau. It is like the eastern border of the middle terrace in roughness, but is higher.

As there has been no faulting or folding of the rocks, the surface features of Bates County are the direct result of erosion. This has acted in proportion to the relative resistance of the interbedded shales, sandstones, and limestones composing the region and has left low, well-marked terrace lines and mounds which form the only prominent topographic features of the area. Except for an occasional sandy knoll or low ridge, the numerous and extensive shale horizons are characterized by level or undulating topography, which gives way to more rolling relief where the underlying limestone has been exposed. Along the streams, particularly in the limestone region, the land is usually quite broken and rough, though there are occasional long, gentle slopes in which it is frequently difficult to determine the limit of overflowed land.

There is a total range in elevation of over 300 feet. The lowest point where the Osage River leaves the county at the southeast corner is less than 700 feet and the highest, which is in the northwest corner, is over 1,000 feet above sea level.

This western prairie region is noted for its many stream channels. The greater part of the drainage of the county is carried by Miami Creek, which rises in the northwest corner and flowing southeast empties into the Osage River in the south-central part of the county. This river enters the county 3 miles south of the middle of the west

county line and receives nearly all the drainage of the southwestern third of the county. Two and one-half miles south of Papinsville it is joined by the Marmiton River. From this point eastward it forms the south county boundary line.

Most of the northern part of the county is drained by Mormon Fork Creek, a tributary of the Grand River which forms part of the north county line. The east-central part is drained by Deepwater, North Deepwater, and South Deepwater creeks and their many tributaries.

The first settlement was at Harmony Mission in 1821, and near where Papinsville now stands. The next settlement was in Shawnee Township, about the year 1830. Most of the early settlers came from Kentucky, Tennessee, and Virginia, although some were from the Northern States. Bates County was organized in 1841 and its present boundaries established in 1855, at about which time there was considerable immigration to this region.

The county was in fairly prosperous condition when the civil war broke out in 1861, but being on the border was made the subject of attacks from both sides until nearly everyone left the county. After the war the majority of the former residents returned and were soon followed by new settlers from Ohio, Indiana, Illinois, and Iowa.

The population, which is given by the Twelfth Census as 30,141, is largely rural and well distributed. Rich Hill, with a population of a little over 4,000, is the largest town and receives considerable support from the adjacent coal mines. It is located in the southern part of the county, on the Missouri Pacific Railway and a branch of the Frisco system known as the Kansas City, Fort Scott and Memphis Railroad.

Butler, the county seat, is nearly as large as Rich Hill and is situated on the Missouri Pacific Railway near the center of the county. The small town of Rockville is situated on the Missouri, Kansas and Texas Railway, in the southeastern part of the county. Merwin, Amsterdam, Amoret, and Hume are towns of from 200 to 600 inhabitants, situated on the Kansas City Southern, in the western part of the county. Besides these there are several small villages throughout the county.

There are nearly 100 miles of railroad in the county and all sections except the northeastern have fairly good shipping facilities. The Missouri, Kansas and Texas Railway crosses the southeastern corner; the Missouri Pacific traverses the county from north to south near the center, and a branch of this system known as the Interstate runs in a general southwest direction from Butler. The Kansas City Southern crosses the county from north to south near the western border.

Kansas City, 75 miles north, is the great market for grain and live stock and is reached direct by the three main roads. St. Louis, 225 miles east, is also easily reached over the same routes. The wagon

roads throughout the county are in fairly good condition a large part of the year. The rural free delivery of mail is in operation in practically all parts of the county, and nearly all the farmers have telephones.

CLIMATE.

Bates County has a distinctly humid climate. The precipitation is relatively light from October to March, inclusive, and is heaviest during the crop-growing season, from April to September, inclusive. There is sometimes a deficiency of rainfall during the latter part of July and August, and corn at such times may suffer unless special care is taken to conserve the soil moisture.

The winters are comparatively mild and open, although occasionally the temperature may fall below zero for a few days at a time. The average annual snowfall is about 20 inches. The snow is seldom very deep and rarely remains on the ground for any length of time. The length of the growing season averages about 157 days.

The following table, compiled from the records of the Weather Bureau station at Harrisonville, 28 miles north, in the adjoining county of Cass, represents approximately the climatic conditions of Bates County.

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

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year.	Total amount for the wettest year.	Snow, average depth.
	° F.	° F.	° F.	Inches.	Inches.	Inches.	Inches.
December.....	31	74	-16	2.0	0.4	1.0	2.8
January.....	27	70	-20	1.4	1.2	.4	4.8
February.....	29	81	-28	2.1	1.2	3.4	6.2
Winter.....	29			5.5	2.8	4.8	13.8
March.....	40	92	1	2.6	.9	3.4	3.8
April.....	54	96	15	3.5	2.0	7.4	1.1
May.....	64	94	28	4.7	2.6	4.6	.0
Spring.....	56			10.8	5.5	15.4	4.9
June.....	73	104	41	4.4	2.2	12.2	.0
July.....	78	112	52	3.9	3.5	10.7	.0
August.....	75	108	45	4.2	5.3	6.4	.0
Summer.....	75			12.5	11.0	29.3	.0
September.....	68	107	29	4.0	1.3	8.1	.0
October.....	56	96	21	2.6	2.1	9.7	.4
November.....	42	79	0	2.1	1.6	.0	.5
Fall.....	55			8.7	5.0	17.8	.9
Year.....	54	112	-28	37.5	24.3	67.3	19.6

Average date of the last killing frost in spring is April 13, and of the first in fall October 18.

AGRICULTURE.

The agricultural history of Bates County is very similar to that of the entire western prairie section. The pioneers found an exceedingly rank growth of prairie grass covering vast areas, broken only by narrow belts of timber along the larger stream courses. As they needed lumber for building, wood for fuel, rails for fences, and water for general purposes, they settled along the streams, where timber and water were available. Wild fruit, game, and fish were also abundant in such locations.

A few acres of timber were cleared, the product utilized, and the land planted to corn. Usually some adjacent prairie land was broken and also planted to corn. Wheat, too, was one of the first crops. Spring wheat was tried at first, but soon gave way to the winter variety. Mills for grinding the wheat and corn were early established along the streams in different parts of the county. It is claimed that the yields of grain were practically the same from the virgin soil as they are at present, the conclusion being that improved methods of the present have about compensated for the greater original fertility of the soil.

Agriculture was completely demoralized during the closing years of the civil war, and in the late sixties more than half of the land was advertised for sale to pay taxes. But with the close of the war many of the northern soldiers who had seen the country and most of the former inhabitants returned, and farm operations began with increased vigor. By 1868 about 10 per cent of the land was in cultivation and the acreage cultivated has increased rapidly until now only a very small percentage remains unbroken.

In the early seventies chinch bugs became a serious pest and by 1874 wheat had been practically abandoned because of them. In the fall of 1874 swarms of grasshoppers appeared and literally cleared the country of all vegetation, leaving the farmers in such a condition that outside help was necessary to relieve the suffering. The grasshoppers came again in the spring of 1875 and destroyed the young crops, but they disappeared in June; corn was again planted, and the crop of that year was the biggest on record.

The chinch bugs had been starved out by the grasshoppers and the land was cleared of weeds, which, together with the abundant and well-scattered rainfall, made conditions reassuring for crops. With the disappearance of the chinch bugs wheat was generally cultivated until about 1880, when the bugs again became numerous and the crop became of minor importance. The years 1901 and 1902 were unfavorable to the chinch bug and it was practically exterminated. Since that time wheat has regained its former importance.

With the extensive free range it was natural that stock raising should early become an important industry. The cattle were raised

and largely fattened on the range, though they were fed what corn was available, as this was the only way in which corn could be easily marketed. Prior to 1870, when the Missouri, Kansas and Texas Railway was built, giving connection with the St. Louis markets, stock was driven 50 miles north to Pleasant Hill and there shipped to Kansas City. With the shipping facilities provided by later railroads, young stock was shipped into the county and turned into fenced pasture and later fed for market. This industry continues to be one of great importance in the county.

Some of the early settlers who came from the south tried cotton growing and a gin was at one time in operation, but cotton has long since been abandoned because of its uncertainty. Castor beans, at one time produced to some extent, were abandoned chiefly on account of the great amount of labor involved in handling the crop. Clover at first did not seem to do well, but in recent years it has gained in favor rapidly. Flax has been grown for many years, though the acreage has declined and it is not now one of the important crops. Oats apparently reached their maximum production in 1870, when the acreage was about 32,000 and the average yield per acre over 25 bushels. In recent years the area sown has been about 14,000 acres. Broom corn is still grown in certain localities, but is not nearly as important a crop as it was formerly. Lately the acreage of sorghum and Kafir corn has been increased somewhat. Tobacco has been grown for home use for many years, and present indications are that it may become a commercial crop. Alfalfa and cowpeas are comparatively new crops which are certain to be general crops in the near future. Indian corn is and always has been the most important and main money crop of the area. It has been grown in the same fields continuously as long as a profitable yield could be obtained. As the crop is almost entirely fed to stock no particular varieties are given preference and but little effort has been made to improve the strains by seed selection. Seed corn is usually picked out of the crib, and though some effort is made to select the best-looking ears this method must necessarily result in ultimate deterioration of the product. There are fortunately a few farmers who are paying more attention to varieties and who are employing modern methods of seed selection. Of yellow corn, Ried's Yellow Dent is preferred by some, and of the white varieties the Farmer's Interest and St. Charles White. The greater part of the crop is drilled in rows about 4 feet apart and 15 inches between kernels, but the best farmers condemn this practice and prefer the check-row method in order to permit more thorough cultivation. As it is important to keep corn clean from weeds and grass, which are certain to injure the crop, there seems to be sufficient reason for discouraging the practice of drilling.

Modern machinery, including weeders and riding cultivators, frequently the double-row, are in general use in the culture of corn. Late cultivation of the crop with a one-horse implement, it seems, has never been tried, but it is very probable that during short droughts this practice would be found profitable, as much moisture now lost through evaporation would be retained in the soil for the use of the crop. The crop is usually harvested by hand, though the harvester is frequently used, and the fodder shredded and fed to stock. The cornsheller is almost unknown. The small producer disposes of his crop in the ear, or sometimes in the field, to the cattle feeder, who feeds it in the ear. Some corn is occasionally shipped from the county, and this is shelled at the elevators. Probably as much grain is imported for feed.

More money is brought into the county directly from the sale of live stock than from any other source. The larger landowners almost invariably feed stock of some kind, buying much of their grain from tenants or the owners of smaller farms, keeping most of their own land in permanent pasture. Formerly most of the cattle fed were raised in the county, but recently the larger number have been imported in carload lots from Kansas City. These cattle, mostly steers, are grades, though some are of very good quality. The home-grown cattle are usually of Shorthorn or Hereford blood and of excellent quality. Some Angus cattle were also seen. Several pure-bred herds exist in the county, and cattle raising seems to be a thriving industry.

All of the farmers raise hogs, some making it more or less a specialty. Some very fine pure-bred pens were seen. Poland Chinas are probably the most common, though Duroc-Jerseys or Red Rocks are numerous. A few Berkshires and Chester Whites are also seen. A first cross between the Poland China and Duroc-Jersey is very popular with a few farmers, and as has been the experience in other localities this cross is more prolific and makes better feeders than the pure-bred stock.

The raising of horses and mules is quite an industry, and though no single farm is perhaps devoted entirely to this branch the number of farmers who have a few head for sale is large. These are usually bought up by a few men who improve their market condition before shipping them to distant points. The sheep industry is growing, as there is considerable land well suited for pasture.

Dairying is practiced to a limited extent in nearly all parts of the county. Separators are common and only the cream is sold, a ready market for which is found at the creamery in Butler and also at substations in other towns. Notwithstanding the interest in dairying there is only one silo in the county at the present time. There is no more economical way of keeping up the flow and quality of milk

during the time of year when the cows are not on pasture than by feeding silage.

Winter wheat is a secondary money crop. The most common variety is the Mediterranean, but in a recent test the Poole variety gave somewhat better yields. The crop is usually sowed with a drill by October 1. The chinch bug is not at present a serious pest, and the crop is seldom damaged, except by heaving and occasionally by hail or rust. The use of commercial fertilizers in growing wheat is becoming general. A packing-house brand containing 2 per cent nitrogen, 11 per cent phosphate, and 2 per cent potash is commonly used. The quantity applied ranges from 100 to 150 pounds to the acre. Fertilizer is said to give an increased yield of 5 to 9 bushels per acre. Much of the crop is marketed at the local mills, though some is shipped out of the county.

Timothy and clover constitute the most important hay crop. Timothy seed is usually sowed with the wheat in the fall and the clover in the early spring. Flax is a better crop than wheat to sow with the grass. The hay is nearly all consumed on the farm. There seems to be a tendency to keep the land in meadow longer than the quality of the hay obtained warrants. The pasture and meadow can be maintained in much better condition by mowing the annual weeds, which are abundant, then disking and sowing more seed at the proper time. The amount of feed on many of the pastures could be greatly increased by this method, though many of them should be broken up. Japan clover, *Lespedeza*, was seen growing along the roadsides in many parts of the county, but its value in the pasture seems not to be fully appreciated and more effort should be made to establish it, particularly in sheep pastures.

The oat crop is very uncertain. Occasionally yields of 50 to 60 bushels per acre are obtained, but frequently the crop is not worth cutting. While there are several contributing causes for these failures it is believed that the climatic conditions are largely responsible. The sun frequently scalds the plant during its growth; therefore it is important to get the seed in the ground as early as possible in the spring. Spring frosts very seldom injure the crop permanently. Volunteer oats in the spring are quite common and are reported to mature earlier and make stronger growth than those sowed in the spring. This suggests at once the possibility of creating by selection from these volunteer oats a winter oat for this region which will give surer and better yields than the present varieties. Some improvement could probably be made by seed selection and cleaning and in the preparation of the seed bed. The amount of seed broadcasted and drilled is estimated to be about the same, though from reports it seems that drilling insures somewhat larger yields. The Texas red oat is most commonly grown, though it is said the seed deteriorates rapidly.

Flax is a secondary crop. The seed is usually drilled in, though frequently sowed broadcast and harrowed or brushed in on very well-prepared land. Timothy and clover is sown with it, for as a nurse crop for grass flax is unequalled. Its open foliage allows more sunshine to reach the young grass than when wheat or rye are used, and the grass suffers less when the flax is removed. It is usually cut, bunched, stacked, and thrashed. The seed alone is sold, no use being made of the fiber. The yield averages about 8 bushels to the acre, and the average price is about \$1 per bushel. The straw is commonly fed to stock.

Experience has shown that flax should not be grown on the same land oftener than once in five years, because of the disease known as "flax wilt." Owing to the low yields obtained this crop is not extensively grown.

Some sorghum is grown. It is used in the manufacture of sirup, which is worth about 50 cents a gallon. It is not produced on a large commercial scale. The best quality of sirup is made from sorghum produced on the Oswego silt loam, though a larger yield per acre can be secured from some of the heavier soils.

Kafir corn is grown as a forage crop, and its production is encouraged because it makes an abundance of valuable supplementary feed.

Market gardening is followed by a few farmers, chiefly to supply the local markets. Watermelons are an important truck crop, the Wigger melon being especially popular. The Sweetheart variety is the most common.

Cowpeas are becoming a general crop, particularly on the Oswego silt loam. The Whip-poor-will variety is in most common use. Cowpeas are frequently drilled with a corn planter on wheat stubble in July, cut for hay in October, and the pea stubble immediately plowed under and the land planted to wheat again. This has been found to be very beneficial to the succeeding wheat crop. When cowpeas are harvested for seed they are made the only crop of the year. Some farmers have this year (1908) planted cowpeas in the corn after laying by the latter crop, and this practice is to be commended.

Some impetus is being given to tobacco production. The crop has been grown for years by a few who learned how to grow it in Kentucky, and after settling in this county continued its production. These have for the most part sold their crop at retail, as no market is readily available. A farmer on Miami Creek cultivates a small patch of Golden Leaf, securing about 150 pounds on one-eighth of an acre, which sells for about 20 cents a pound. Another farmer has raised twenty-one crops of White Burley. With heavy manuring it produces from 1,000 to 1,200 pounds per acre, which retails at from 12 to 15 cents per pound. He plants from May 25 to June 15 and harvests in August. He claims that he makes a clear profit of about \$75

an acre on the few acres planted to this crop each year. Land on which timber has grown is considered absolutely essential for tobacco production.

The growing of alfalfa is in an experimental stage. It is being grown to a small extent on several different types of soil in the county. It is safe to predict that alfalfa will in time become one of the important crops of the area. On the uplands inoculation and liming will probably be necessary to secure the most successful yields.

On nearly every farm some orchard fruits are produced for home use. This, however, is not recognized as a fruit region and but one commercial orchard is found in the county.

That certain crops are adapted to certain soil types is fairly well recognized. The truck crops are almost invariably grown on the Bates loam and Boone fine sandy loam. The Summit silt loam and Crawford silt loam or the bottom-land soils are best adapted to corn and are more extensively cultivated to this crop than are any of the other types. Wheat, oats, and grass cover a large acreage on the Oswego silt loam, which is admirably adapted to these crops. Though these adaptations are commonly recognized, they are not always taken advantage of. One reason for this is the absence of systematic crop rotation.

Each farmer should adopt a crop-rotation system which will answer the requirements of his own farm and the different soil types occurring thereon. Soils deficient in humus, like the Oswego silt loam, should have a rotation which will constantly replenish the humus supply, while the physical condition of some of the other types is the important point to be kept in mind in planning the crop rotation.

On a typical grain farm in the county the following system of cropping is practiced: Mowing land is broken in the fall, leaving it exposed in the furrow over winter, and the seed bed prepared in the spring and planted to corn. The cornstalks are broken down after harvest, and if the weather permits the ground is again plowed in the fall and planted to corn the second year. If possible the land is plowed the following fall, but if not the seed bed for oats the third year is prepared by disking and the seed put in as early as possible. The oat stubble is plowed immediately after harvest and as shallow as turning under the stubble will permit. Wheat is planted that fall and also the fall of the fourth year, when timothy seed is sowed with the wheat and the following spring clover seed is also sowed. The land is kept in mowing for two years and then used again for the production of corn. This makes a seven-year rotation which offers opportunities for many variations. The main criticism is that it includes no leguminous crop. Cowpeas could be put in the corn and also after the first wheat crop, and if plowed under would effectually maintain the humus supply of the soil.

On another farm where a longer rotation is practiced flax is introduced when seeding the land to grass. The entire crop of clover is plowed under in the late summer and no crop is taken off the land that year. It is claimed that the loss of a crop in this way is compensated for by the increased yields of the following crops. Where it is not convenient to follow this plan, catch crops of cowpeas can be introduced and the supply of organic matter maintained in this way.

The average size of farms is about 120 acres, and from the census reports it appears that the percentage of farms operated by owners is decreasing. This is due partly to the fact that some farmers have retired and rented their land and partly to the immense accumulation of land in the Scully estate. Cash rent ranges from \$2 to \$3 an acre. On a share basis the landlord receives from two-fifths to one-half of the crops on shares. Farming land may be purchased at \$25 to \$60 an acre, though more highly improved and favorably situated farms are held at the higher price.

SOILS.

Bates County lies within the nonglaciaded part of the western prairie region. Its upland soil is therefore residual, or derived from the immediately underlying rock. The rocks of this region belong to the Pennsylvania division of the Carboniferous and consist of interbedded shale, sandstone, and limestone. Shale is the predominating rock and may vary from argillaceous to arenaceous in the different beds or even in the same stratum, while the layers of limestone and sandstone are comparatively thin and uniform. Faulting or folding of these rocks is nowhere in evidence, the strata lying nearly horizontal, with only a slight dip to the northwest. It is apparent that were the present surface level the soil would be practically the same all over the county. Such a condition, however, has been prevented by erosion, the result being that with the differences in elevation the different strata of rock have been exposed to the processes of weathering and soil formation. As the different kinds of rock give rise to widely varying soils, it is easily seen that topography is a very important factor in the location of any particular kind of soil.

Soils of different texture—that is, composed of different proportions of sand, silt, clay, etc., but closely related through source of material, method of formation, coloration, and other characteristics—constitute a soil series. Some of the soils of the area are of rather local occurrence and of questionable relationship and are given local names.

A distinction is made between the residual soils, according as they are derived from shales and sandstone or from limestone. The shale and sandstone have entered more largely into the soils of the county than the limestone and have given rise to soils of three series

and to one miscellaneous type more or less closely related thereto. The Boone silt loam and the Boone fine sandy loam are characterized by very light gray surface soils, the Bates silt loam and Bates loam by gray surface soils, and the Summit silt loam and Summit clay by dark-gray or nearly black surface soils. The distinguishing feature of the Oswego silt loam is the presence of a so-called hardpan in the subsoil. The limestone gives rise to the Crawford silt loam previously mapped in Kansas.

The colluvial class of soils is represented by the Sedgwick black clay loam, which in its material is closely related to the Summit soils.

The bottom land or alluvial soils are related to each other in the source of their material and the manner of their formation, but differ in respect to color, position, and elevation in the bottoms.

The Osage silt loam occupies the creek bottoms and higher elevations along the larger streams, while the Osage clay occupies the depression in the wider bottoms and belongs to a series characterized by the dark color of the soils. Very little sandy material or loam was found in these alluvial deposits and the loam type was not recognized, though certain phases of the Osage silt loam approximated a soil of lighter texture. There are along some of the streams areas locally called second bottom. There is every reason to believe, however, that the materials here are not of alluvial origin and the soils are therefore grouped with the upland types. Along some of the smaller streams there exist a few areas of true terrace deposits, but these were so limited that they could not be shown in a map of the scale used.

The following table gives the name and extent of each of the types of soil found in Bates County:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Oswego silt loam.....	200,192	36.1	Crawford silt loam.....	11,072	2.0
Summit silt loam.....	152,512	27.5	Sedgwick black clay loam....	2,496	.5
Osage silt loam.....	71,808	12.9	Rough stony land.....	2,240	.4
Bates silt loam.....	50,880	9.3	Boone silt loam.....	1,984	.3
Osage clay.....	23,232	4.2	Boone fine sandy loam.....	960	.2
Bates loam.....	21,888	3.9			
Summit clay.....	14,976	2.7	Total.....	554,240	.....

OSWEGO SILT LOAM.

The characteristics by which the Oswego silt loam are easily distinguished from the other types of the area are its prairie vegetation, gray color, ashy feel, level surface, and the sharp line of demarcation between soil and subsoil. The surface soil consists of 8 to 10 inches of dark-gray, rather loose structured silt loam, which when wet becomes a very dark gray or almost black but when dry is very much

lighter colored. It is locally known as "white ashy land." The subsurface soil from 10 to 18 inches is always lighter colored, contains very much less organic matter, and has a slightly higher clay content than the surface soil and as a consequence tends to clod considerably. It also becomes quite compact and hard when dry. Immediately below this material lies the heavy, compact, somewhat tenacious silty clay subsoil which extends to a depth of 36 inches, where it becomes friable and crumbly, decreasing in clay content. From 18 to 28 inches this material is usually much darker than the overlying soil, frequently being almost black, but rapidly changes to a grayish yellow with a faint greenish tinge.

This soil type as mapped in this survey consists of two distinct phases that are universally recognized not only by the student of soils but by the farmers who occupy it. The difference between the two phases is one of structure rather than texture, yet it is one of great importance in the agricultural utilization of the soil. One phase is the flat-land phase and the other the rolling-land phase. In both the surface soil is a gray silt, and in both this is underlain by a darker, tougher, more clayey subsurface. In the flat-land phase, however, the boundary between the surface and subsurface is a very sharp one; in the other it is more indefinite. In the former the subsurface is a hard, tough, dark, brownish-clay with some red mottlings. In the latter it is a dark, brownish-gray silty clay, usually without the red mottling and usually neither so hard nor so tough as the former. In the former the subsoil is a yellowish-gray to bluish-gray silty clay, with a yellowish to brownish mottling, but considerably less tough than the subsurface. In the latter the subsoil is a yellowish-gray silty clay much more nearly uniform in color than that of the former phase.

The rolling-land phase has much better surface drainage than the other and its underground drainage is also better. Its color also is usually somewhat darker.

The rolling-land phase constitutes much the larger area of this type in the county. Practically all of the type in the southwestern corner of the county belongs in it and all the eastern part of the great area of this soil that lies west and northwest of Butler.

The main flat-land areas are in a belt running northeast and southwest through Adrian, along the foot of the third terrace, in the southeastern corner of the county.

The farmers will admit that the flat-land phase is "hardpan" land, but they will not admit that the rolling-land phase can be correctly designated by that term.

The Oswego silt loam is the most extensive soil type in Bates County, occurring in every township. It is the predominating type in the northwestern two-thirds, where it occupies many entire sections. It also occurs extensively in the southwestern and south-

eastern townships. The area of its least development lies from Pleasant Gap northward to the county line.

The type is intimately associated with level or undulating topography and is always limited by a rolling surface whether that surface lies above or below the general level of a given area. It occupies the wider divides, gentle slopes, and the rather low-lying, so-called "second bottoms" along the rivers. The last-named position is the lowest level at which the type is developed and includes elevations in the uplands from below 750 feet to something over 800 feet. Its highest elevation reaches more than 1,000 feet in the northwest corner, and the remainder of the type from a little below 850 feet to more than 900 feet above sea level.

Though perfectly flat areas are not frequent and there is apparently enough fall to afford good surface drainage, the damage done to crops by excess of moisture is very great. The present season was a severe one in this respect, and much of the corn was abandoned as worthless early in the season. The heavy subsoil is to some extent accountable for this, as it greatly retards the downward movement of drainage waters. This trouble can be largely relieved by tile drains, which, though results might not be immediate, would ultimately break up the close structure of this material naturally loose and crumbly when exposed to the air. Narrow, open ditches or even furrows would be effective in draining many of the small depressions in which corn is a failure in wet seasons. There is sufficient fall in almost every case for the proper construction of drainage systems. In the few instances where tile drains have been installed they have given good results.

The formation of the Oswego silt loam is not clearly understood in its details. It is evidently connected with shale formations, as it is underlain at greater depth by silt shale rock and it would seem that the subsoil at least was derived therefrom. But the formation of the 18 inches of light silt soil can hardly be explained by residual processes alone, because of the great difference between it and the underlying subsoil and the sharp line of demarcation between the two. The dark color in the upper portion of the subsoil suggests that it may be due to an accumulation of organic matter at a time when it was the surface soil and that the overlying material is a later deposit. But the differences in elevations at which the type is found would preclude the theory of water deposit and the material is somewhat different from that heretofore recognized as loess or wind blown. It is possible to account for it by translocation or gradual movement of the finer particles from the surface to the subsoil, though the sudden change in material almost refutes that theory. That the subsoil is largely residual material from the underlying shale seems fairly certain, but that there has been some other process involved in the

surface and subsurface soil is also plain, but what it is is still a matter of conjecture.

The original vegetation of this type was prairie grass, which grew very rank. Timber growth was probably prevented by prairie fires. All the general crops of the area are grown extensively on this soil. Corn is the leading crop, and more white corn is grown than yellow, it being the general impression that white corn will yield better than yellow on the "thinner" soils. The corn crop responds remarkably well to thorough cultivation, and the remarks regarding cultivation and planting of corn in the chapter on agriculture apply particularly to this type.

Oats yield from 10 to 40 bushels, flax from 6 to 10 bushels, broom corn about one-fourth ton, and hay about 1 ton to the acre. Clover seed usually yields about three-fourths bushel to the acre, though as high as 5 bushels were reported. Cowpeas are grown to some extent, but not nearly so generally as they should be. Alfalfa was seen growing on this type. The roots seem to penetrate the heavy subsoil, and this crop should succeed where conditions are made as favorable as possible.

Besides drainage, the two main factors controlling crop production on this soil are the maintenance of a supply of organic matter and the conservation of moisture. When the prairie sod was first broken an abundance of organic matter had accumulated from the roots of the prairie grass. The soil then was loose and open, but through many years of constant cultivation the original supply of humus has been largely depleted, and, as a consequence, the soil particles have become more or less compact, thus indicating rapid capillarity and the loss of soil moisture at a time when it is most needed. The deficiency of humus is also largely responsible for the cold, soggy condition sometimes found in the type. In other ways, the loss of humus has been detrimental to crop production, and the addition of vegetable matter will do much toward improving this type. The humus content can best be increased by applying stable manure or by plowing under cowpeas, clover, manure, or any green manuring crop. The deeper this can be incorporated in the white subsurface soil the better will be the results. Because of its effect upon the soil drainage, the heavy subsoil is usually regarded as a detriment, but it may really be advantageous in that it prevents leaching. During the progress of this survey an examination was made of a field which had been fallowed and a dust mulch constantly maintained, and during the driest part of the summer, when the crops were suffering for moisture, it was found that the soil and subsoil were so moist that the change from subsurface to subsoil was scarcely discernable. In this connection it is strongly recommended that the cultivation of corn be continued with one-horse shallow cultivators beyond the time when it is usually "laid by" and

well into the season, thereby conserving moisture for the crop at a time when it needs much and usually gets little.

Very little fertilizer except barnyard manure is used on this type. It is said that applications of manure are effective for a period of five to seven years. Commercial fertilizer analyzing 2-10-2 applied to corn gives an increase yield per acre of 7 bushels.

The average results of mechanical analyses of samples of the Oswego silt loam are given in the following table:

Mechanical analyses of Oswego 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>
20004,20010...	Soil.....	.01	1.2	0.9	1.2	1.3	77.8	17.4
20005,20011...	Subsoil.....	.1	1.7	1.5	1.7	2.4	74.1	18.8
20006,20012...	Lower subsoil...	.0	.8	.7	1.3	2.5	55.4	39.1

SUMMIT SILT LOAM.

The Summit silt loam is one of the most important soil types of the area. The surface soil is uniformly a very dark gray or black rather heavy silt loam which may vary in depth from 6 to 20 inches, though averaging about 10 inches deep. A distinguishing characteristic of this material is its constant tendency to granulate or break up into small aggregates, with the result that it does not run together, pack, bake, or crack. The subsoil is quite variable. Immediately below the surface soil, usually at about 10 inches, the material becomes lighter colored and slightly heavier, though maintaining the granular structure to about 20 inches, at which point granulation usually disappears and the clay content increases rapidly with depth, the deeper portion being a yellowish or greenish tinged, gray silty clay, or clay loam very similar to the deep subsoil of the Oswego silt loam. An extensive phase of the subsoil occurs in which the material is not heavier than a clay loam and the color is yellowish-gray mottled with reddish brown or brownish red. The granular structure is maintained to some extent in this phase throughout the soil profile. Outcrops of limestone rock are frequently found and small, rounded chert gravel are locally disseminated through the subsoil. Small iron concretions also frequently occur and are largely responsible for the mottled condition of the phase.

Though there is no township in which some of this type does not occur, the most extensive areas lie to the south and east of Butler and in the northeast part of the county.

The topography is generally rolling, the type occupying narrow ridges and slopes and higher mounds. It occasionally continues over

rather flat areas lying between ridges, and flat areas also occur on the type of the higher elevations. The prevailing topography insures fairly thorough natural drainage, but the character of the soil is such that water does not penetrate it as rapidly as is often desired, and in many places tile drainage would be very beneficial, not only in removing surplus water, but in aerating the soil.

The greater part of the type occurs in the breaks of streams, where the elevation is from 850 to 900 feet or below that of the greater part of the Oswego silt loam, though the areas in the northwest corner and around the mounds lie above the greater part of the latter type, the elevations there being from 950 to 1,000 feet.

Locally, the Summit silt loam is known as "black limestone land," implying that it is derived from limestone rock, which, however, is not the case. It is a residual soil formed from strata of shale, above and below which occur thin strata of limestone which frequently outcrop and give the type its local name. The limestone has probably contributed some material to the soil, but the proportion of such material is relatively small. The uniformly dark or black color of the soil is probably due more or less to the thin layer of black shale which immediately underlies the limestone. In low spots on some of the more level areas of this type a white crust was seen closely resembling alkali, but these areas were small and of little consequence.

Like the Oswego silt loam, almost all of the Summit silt loam was originally prairie and when first broken up was very loose and friable. Some of the type, especially along streams, supports a scant growth of persimmon, pecan, and oak.

This is the best upland corn soil in the county and is usually so regarded. The mellow surface, good drainage, and heavy subsoil fit it especially for this crop. By many it is considered the best wheat soil of the area also, but if the Oswego silt loam is properly handled it will probably outrank this soil in the quality and yield of wheat.

That portion of the type originally timbered produces good tobacco. Just what influence the timber has had is not understood, but the fact remains that where timber has stood the soil will produce good tobacco, while the prairie will not.

Some alfalfa was seen growing well on this type, and there seems to be no reason why it should not succeed as a regular crop.

Corn yields from 35 to 40 bushels, wheat 15 to 20 bushels, hay 1 ton, and flax 6 to 8 bushels per acre.

Fertilizer is not extensively used, but applications of 150 pounds of a 10-2-2 grade give an increase of about 5 bushels of wheat, indicating that the soil will respond to applications of phosphorus. Fall plowing of this type is considered essential for best results.

The Summit silt loam is nearly all under cultivation and is regarded as the strongest soil of the area for general crops. It is valued at \$50 to \$80 an acre.

The following table gives the average results of mechanical analyses of fine-earth samples of this soil:

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>
20015, 20017	Soil	0.2	1.3	0.9	1.9	3.7	61.5	30.5
20016, 20018	Subsoil .....	.5	1.9	1.0	2.8	4.4	48.5	40.7

BATES SILT LOAM.

The soil of the Bates silt loam is a loose, mellow silt loam of a dark-gray color to a depth of 8 to 10 inches, at which depth it becomes a yellowish-gray, mellow silt loam. When wet this material has a peculiar mushy feel, but when puddled and allowed to dry it becomes very hard and compact. The deeper portion of the surface soil, which apparently contains less organic matter than the overlying material, has a tendency to run together. There is frequently a rapid gradation between the subsurface soil and the subsoil which is found at a depth of 20 to 36 inches. It is a yellow and red mottled clay loam which becomes slightly heavier with depth, and is seldom plastic or sticky though frequently somewhat tenacious. When dry it becomes quite hard and impenetrable. The heaviest phase approaches closely the mottled subsoil phase of the Summit silt loam and in places where a part of the surface soil has been removed by erosion the land is likely to be confused with the Boone silt loam. The largest area of Bates silt loam lies in the vicinity of Hudson, in the southeastern part of the county. It occurs, however, in all parts of the county associated with the Oswego silt loam. It lies both immediately above and below that type, particularly in its lowest lying areas, and is separated from it by rather distinct boundaries. It is also frequently associated with the Bates loam, areas too small to be shown on the map being quite commonly developed in that type.

Areas of this soil form hill slopes, narrow ridges, and low elevations, along the breaks and streams, and in low places in the main body of the Oswego silt loam. While its topography for the most part favors thorough drainage, along the boundaries with the Oswego silt loam it is very frequently wet and soggy, owing to the accumulation of seepage waters which flow out of the latter soil along the surface of the compacted subsoil. The same conditions are found where water is obstructed in its downward course by shale and sandstone strata in the subsoil of the Bates loam. So far but little effort has been made to tile drain these seepy areas, though this would be entirely feasible.

The Bates silt loam is a residual soil formed by the disintegration of soft shale which immediately underlies it. The material is closely allied to the Oswego silt loam, but being modified by drainage conditions has developed its characteristic differences. Much of this soil was originally timbered, though some was also in prairie. Most of it has been cleared, but along the streams some hickory, sycamore, and oak still remain.

The ease with which the soil can be cultivated, its rather heavy subsoil, and ability to hold fertilizers make it a popular and valuable soil for general farming. Corn yields on an average about 30 bushels, wheat 12 to 15 bushels, and flax 8 bushels to the acre. Much of the type is utilized for the production of hay, partly because it is likely to gully and wash under cultivation and partly because the areas affected by seepage can best be used for this purpose. Hay yields from 1 to 1½ tons to the acre.

On that part of the type originally timbered a very good quality tobacco is grown when heavily manured. The soil is often deficient in humus, which needs to be supplied in order to get the best results.

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

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>
19989.....	Soil.....	0.0	1.2	0.9	6.2	9.7	67.2	14.6
19990.....	Subsoil.....	.6	1.1	.9	5.9	12.8	57.3	21.3
19991.....	Lower subsoil...	1.5	1.6	.6	4.0	5.1	50.2	36.6

CRAWFORD SILT LOAM.

The Crawford silt loam, locally known as "red land," consists of about 10 inches of dark brownish gray to dark-brown silt loam, underlain by a rather dark brownish-red subsoil, which becomes heavier and more intense in color with depth until at 36 inches it is a nearly red, somewhat plastic and sticky clay. Except for the slight brownish cast the soil closely resembles that of the Summit silt loam, being granular and rather mellow, which makes it easily tilled. It is usually well supplied with organic matter.

The subsoil is underlain with limestone rock which is frequently struck in boring at from 24 to 36 inches. The type is frequently found in isolated areas within bodies of the Summit silt loam, particularly in the region north of Pleasant Gap and in the northwest part of the county.

Stratigraphically the most of the type is developed immediately above the shale which gives rise to the Summit silt loam and below

the shale from which the Bates loam and Oswego silt loam are derived. It is found on gentle slopes and narrow ridges and has a level to undulating topography and good natural drainage. The subsoil is no doubt true limestone material derived from the underlying rock, but the soil represents a mixture of shale material washed from, or the remnants of, the Summit silt loam or Oswego silt loam, with material of limestone origin.

The type is now practically all under cultivation or in pasture or mowing. It has all the essential characteristics of a corn soil and is considered by many as the best corn-producing soil of the area. The yields are about the same as on the Summit silt loam. Corn yields 35 to 40 bushels, wheat 12 to 18 bushels, oats 15 to 20 bushels, and hay 1 to 1½ tons to the acre. So far as known no commercial fertilizers are used on this soil.

There is an eroded phase of the type occurring in small areas within the Summit silt loam. Conditions favoring the formation of this phase exist only on sharp narrow ridges or the higher mounds. The soil is a mellow, somewhat granular silt loam, of a reddish-brown to red color, with a depth of about 8 inches. Limestone rock is found at depths ranging from 12 to 48 inches and limestone fragments occur frequently over the surface and in both soil and subsoil. This phase of the Crawford silt loam, excepting the more stony parts, is adapted to the same crops as grown on the main areas of the type.

The following table gives the average results of mechanical analyses of soil and subsoil of the Crawford silt loam:

Mechanical analyses of Crawford 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>
19994, 19996, 19998..	Soil.....	0.1	1.2	0.5	1.2	3.0	72.4	21.2
19995, 19997, 19999..	Subsoil....	.3	1.0	1.2	1.8	2.8	54.6	37.9

BATES LOAM.

The Bates loam is more or less variable in its texture and color as well as in depth. The typical soil consists of about 8 inches of loose structured light loam, which is brown when moist, but becomes a light gray when thoroughly dry, though often the color is a very dark gray to almost black. The texture is often very fine, closely resembling the Bates silt loam and also the Boone fine sandy loam, and areas too small to map of both these types occur within the boundaries of the Bates loam. The soil is usually mellow and easily tilled, but after heavy rains there is a tendency to form a surface crust which, however, is easily broken up.

The subsoil is usually a solid buff color, though areas with mottled red and yellow occur. The texture is usually a fine sandy clay loam or clayey loam, quite gritty from its sand content and yet made sticky by clay. The percentage of silt is relatively low. Arenaceous shale resembling in color the subsoil is encountered at depths ranging from 18 to 48 inches. This material is soft and appears very sandy, but on crumbling and rolling between the fingers becomes very fine.

The largest areas of the Bates loam lie east of Butler around Sprague and in the vicinity of Foster. It is also extensively developed in the northeast corner. It usually occupies ridges and knolls and in the rougher sections occurs as a distinct terrace. It is found to a slight extent on slopes and in flat areas near the base of hills.

Stratigraphically in the hilly regions it lies immediately above the limestone soil if developed, otherwise, it is found above the Summit clay. It is usually the highest soil, though areas of Bates silt loam and Oswego silt loam sometimes lie at a higher level. Because of its topographic position and texture the natural drainage is nearly everywhere good, and on this account it outyields the other types in wet years.

The Bates loam is derived from the disintegration of arenaceous shale and sandstone strata in the main shale formation, and the variations in the type are largely due to variations in the contributing material augmented by washing and drainage.

Originally areas of this soil formed a part of the prairie. It is now devoted to general farm crops and market gardening. Corn yields from 30 to 35 bushels, wheat 10 to 15 bushels, flax 6 to 8 bushels, and oats 10 to 20 bushels per acre. Considerable trucking is done, and the soil is admirably adapted to that purpose. Watermelons are produced at considerable profit.

The supply of organic matter over most of the type is deficient. The supply of humus and organic matter should be incorporated with the soil as rapidly as possible. This will increase crop production by conserving moisture, an important matter, as the crops are likely to be injured by drought. The use of commercial fertilizers, especially in the growing of truck, has been found beneficial.

The soil is usually regarded as acid, and quite a sharp reaction was obtained in both soil and subsoil with litmus paper, indicating that rather heavy applications of lime should be made.

The following table gives the results of mechanical analyses of the soil and subsoil of the Bates loam:

Mechanical analyses of Bates 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>
20000.....	Soil.....	0.0	0.3	1.0	41.2	9.3	32.3	15.8
20001.....	Subsoil.....	.0	.5	1.0	39.0	8.3	26.2	24.8

BOONE FINE SANDY LOAM.

The Boone fine sandy loam consists of about 8 inches of gray, loose structured, and rather incoherent fine sandy loam, underlain after a rapid gradation by a clayey loam or fine sandy clay loam the upper portion of which is mottled gray and buff rapidly changing to a red with depth. Sandstone or arenaceous shale rock underlies the subsoil at from 10 to 30 inches. Mica flakes and some sandstone and shale fragments occur in both soil and subsoil, and the latter occasionally on the surface. Owing to its friable porous texture this soil can be worked under a wide range of moisture conditions. Only a limited area of this type of soil occurs in Bates County. The largest area is found south of Butler and west of Peru. A few areas too small to be indicated on the soil map are included with the Bates loam.

The type occupies narrow ridges and rather abrupt slopes and consequently has very thorough drainage. It is derived from a micaceous, arenaceous shale and sandstone which are quite soft and easily crumbled. On the slopes, which are usually quite sandy, washing has probably removed some of the finer material and left the sand.

The greater part of the type is under cultivation. Corn yields about 20 bushels, wheat 10 bushels, and oats 10 bushels to the acre. Some truck crops are grown, and the soil is better adapted to such crops than to general farming.

The quantity of organic matter is even less in this soil than in the Bates loam and must be greatly increased to secure the best results. In order to grow clover it will be necessary to give the fields heavy applications of lime to correct acidity, as litmus-paper tests showed the soil to be decidedly acid.

The results of mechanical analyses of fine-earth samples of the Boone fine sandy loam are given in the following table:

Mechanical analyses of Boone fine sandy 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>
20002.....	Soil.....	0.0	0.5	2.9	48.6	11.9	28.7	7.3
20003.....	Subsoil.....	.0	.3	1.7	41.1	9.1	22.3	25.2

SUMMIT CLAY.

The soil of the Summit clay consists of from 5 to 8 inches of heavy adhesive black silty clay or clay. In boring large lumps of the soil are pulled up with the auger. The subsoil to a depth of 36 inches is a puttylike, plastic clay, of a yellowish-gray or greenish

color. Limestone and chert fragments are strewn over the surface and small lime concretions are numerous in the subsoil. Although the soil is naturally very plastic and tenacious, when plowed and exposed to the action of frost it breaks down into a crumbly mellow condition. The areas of the Summit clay are found in the rougher parts of the county southeast of Peru and in the vicinity of Pleasant Gap. The largest areas are in the northwestern part of the county. The type occupies steep slopes, ravines, and very narrow stony ridges. Most of the areas mapped Rough stony land contain much of this type but with more broken topography.

The areas lie just above the Summit silt loam and below the Crawford silt loam, or if the slope is not sufficient for either of those to be developed the Bates loam lies above it. The drainage is usually excessive, though there is apparently no tendency to wash or gully and the soil seems to withstand drought well.

The type is of residual origin. The soil has been derived from a stratum of clay shale which underlies the limestone and as outcrops of the latter are frequent just above it, it is commonly called "heavy black limestone land." Owing to the fact that the shale stratum is very thin the areas of this type are limited. The black color of the soil is due at least in part to the color of parent rock. The limestone and chert fragments on the surface are the remnants of the limestone stratum which at one time rested upon the shale or they have been derived from the outcrops which usually occur on the slopes just above the Summit clay areas. Cultivation of this type is largely confined to the less broken areas, where the soil is more nearly a clay loam. The rougher topography and stony character of the more typical clay areas prohibit farming operations. Most of the area is forested with oak and persimmon, much of which could be profitably utilized for the production of fence posts. Some of it could also be used as pasture; clover and even alfalfa should succeed well, as the soil is high in lime and the drainage is excellent. On areas suitable for tillage corn and wheat yield well, though no definite yields can be given.

The following table gives the results of mechanical analyses of fine-earth samples of the soil and subsoil:

Mechanical analyses of Summit clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
20019.....	Soil.....	0.2	1.7	1.3	4.9	4.6	50.9	36.6
20020.....	Subsoil.....	.9	2.7	1.4	2.8	2.2	43.7	46.2

OSAGE CLAY.

The Osage clay consists of about 18 inches of black heavy silty clay or clay, which grades into a bluish-drab clay subsoil. There is frequently but little change from the soil to the subsoil, both being very plastic, sticky, and tenacious when wet. When dry the surface becomes quite granular and mellow. In the vicinity of old lake beds the subsoil is slightly mottled with brown and is not quite so heavy as over the greater part of the type.

This is a bottom-land soil found in the wide bottoms of the Osage River, in the narrow bottoms of the Grand River along the north-east boundary of the county, and in two small areas in the Miami Creek bottoms. It occupies the lowest levels in the county and the topography is flat. The areas are usually lower near the bluffs and higher near the streams, from which they are separated by a narrow band of Osage silt loam.

Practically all of this type is at present subject to deep and prolonged overflow. A drainage district has been organized for the purpose of reclaiming a part of the type. A large drainage ditch is being cut through the Osage bottoms and it is expected that this ditch will render several thousand acres of the Osage clay suitable for cultivation. The soil has been formed by the deposition of the finer sediments carried by the several streams along which it is found. Its black color is due to the accumulation of relatively large quantities of decaying vegetable remains, mostly the stems and roots of coarse grasses.

The greater part of the Osage clay is now covered with a rank growth of prairie grass, which is usually cut. Some parts support forests of water-loving oaks and pecan. In the timbered areas the soil is somewhat looser in structure, and the surface is usually gullied. Such areas if cleared would be difficult to cultivate.

Even if the drainage ditch under construction prevents overflow of the lands along the Osage it will be necessary to install tile drains in order to make the reclamation complete. Underdrainage, although expensive on account of the need of running the drains at close intervals, is particularly advantageous in having the close structural characteristic of the Osage clay, as it tends to make the soil more open and friable.

This is typical corn soil. Though not much corn has yet been produced on it, with thorough drainage yields of 75 to 100 bushels per acre may be expected. Unless it is found that wheat makes too rank a growth the land should also produce large yields of that grain. It will probably be difficult to make it suitable for alfalfa. Some broom corn is produced on the type but it is too coarse to be of first quality.

Fall plowing, which allows the soil to weather and crumble during the winter, will be found the best practice. In spots which are very heavy and difficult to work an application of lime, which flocculates the particles, will aid in securing good tilth.

The results of mechanical analyses of soil and subsoil of the Osage clay are given in the following table:

Mechanical analyses of Osage clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	<i>Per cent.</i>
20021.....	Soil.....	0.1	1.1	0.6	2.7	1.8	56.5	37.3
20022.....	Subsoil.....	.0	2.1	1.3	9.1	3.0	37.8	46.9

OSAGE SILT LOAM.

The Osage silt loam is the most variable type of soil in the county. The surface soil is usually a light-gray, slightly compact, silt loam ranging in depth from 8 to 24 inches. This material in most instances grades into a heavy silt loam subsoil of somewhat darker color, though it may be underlain by a drab clay loam or in some cases by a black clay. The areas of any one phase are so small that separation seemed impossible, and characteristics other than being a light-colored silt loam on the surface were ignored in mapping. Some small spots of loam were found, but their total area was so small that a separation was not made.

The type occurs in all the stream bottoms and is broken in the wider bottoms only by the Osage clay. Along the Grand and Osage rivers it occupies the slightly elevated land next to the stream channels. It is largely alluvial material deposited in times of overflow, but some areas adjoining the upland probably contain material which has been washed down over the Osage clay and now forms the subsoil. Most of the type is subject to overflow and for this reason is largely left in grass or forest, very little being under cultivation. If the drainage ditch along the Osage prevents overflow, this will be a valuable soil for practically all crops. Alfalfa should do particularly well. Some of the type would be benefited by tile drainage and by incorporating vegetable matter in the soil.

The following table gives the results of mechanical analyses 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>
20023.....	Soil.....	0.2	0.9	0.8	1.0	1.1	66.9	29.2
20024.....	Subsoil.....	.0	1.0	.7	1.0	2.9	63.9	30.2

SEDGWICK BLACK CLAY LOAM.

The Sedgwick black clay loam consists of from 12 to 18 inches of somewhat plastic though slightly granular clay loam or silty clay, which grades into a gray, plastic, and sticky silty clay or clay subsoil. This material closely resembles the deep subsoil of the Oswego silt loam and also somewhat the subsoil of the Summit clay. Frequently a drab color is also developed in the upper subsoil.

This is relatively an unimportant type, occurring principally at the foot of the highlands in the northwest part of the county. The surface soil is largely colluvial material which has been washed from the adjoining higher-lying Summit clay or silt loam areas. The subsoil is probably residual material from shale.

The type occupies rather flat depressions, and needs drainage. It is largely used for pasture and mowings, though if drained, it would be an excellent corn soil. Possibly it would prove too strong for wheat. As the areas are not large, sufficient fall exists for the proper installation of tile drains.

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

Mechanical analyses of Sedgwick black 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>
20013.....	Soil.....	0.0	1.0	0.5	2.2	9.9	57.9	28.3
20014.....	Subsoil.....	.2	1.1	.6	1.8	8.5	61.1	26.8

BOONE SILT LOAM.

The soil of the Boone silt loam consists of 6 to 10 inches of light-gray to almost white, floury, and ashy silt loam. The subsoil to a depth of 36 inches is a rather compact yellow silt loam or light clay loam. The material of the soil and upper subsoil in some areas closely resembles loess.

Isolated areas of this type of soil are found throughout the county. They occupy rather low-lying flats and slopes usually broken by short water courses and in some places form narrow strips along streams between the bottom land and the Oswego silt loam or Bates silt loam. The soil is evidently composed of the same material as these types, though it has acquired distinct characteristics through the modification of these materials by different drainage conditions. The presence of timber growth, principally oak and hickory, has doubtless had some influence in the formation of the type.

But little of the type is under cultivation and the yields are low. The incorporation of organic matter would greatly improve this soil. No sample was taken for mechanical analysis.

ROUGH STONY LAND.

In some parts of the county there are areas which are too rough and stony for cultivation. These have been indicated on the map as Rough stony land. They are usually associated with the Summit clay. They afford some scant pasture, but their chief use will be the production of timber.

SUMMARY.

Bates County is situated in southwest Missouri. It has an area of 554,240 acres or 866 square miles.

The surface features have been developed by erosion and influenced by the relative hardness of the limestone, shale, and sandstone which form the country rock. In general, the topography is undulating to gently rolling, with rougher areas in the limestone region along the streams.

The county is drained almost entirely by the Osage River and its tributaries, though the Grand River drains the northeastern part.

The first settlement was a mission established near Papinsville in 1821. The earlier settlers came from Kentucky, Tennessee, and Virginia, but in late years the immigration has come from the north and immediate east.

The present population is largely rural and well distributed. Rich Hill is the largest town, Butler is the next in size, and many other small towns are scattered over the county.

There are about 100 miles of railroad in the county. The Missouri, Kansas and Texas Railway crosses the southeast corner; the Missouri Pacific and the Kansas City Southern run parallel north and south across the county in the middle and near the western boundary, respectively; the interstate branch of the Missouri Pacific runs west from Butler into Kansas, and a branch of the Missouri, Kansas and Texas runs into Rich Hill from Kansas. Kansas City, 75 miles north, is the principal market, though St. Louis is also easily reached.

The climate is distinctly humid and adapted to all general farm crops.

The raising, fattening, and marketing of live stock is the most important industry.

A large number of crops are grown, which, named somewhat in the order of their importance, are as follows: Corn, wheat, timothy and clover, oats, flax, sorghum, Kafir corn, millet, cowpeas, tobacco, and alfalfa. Corn is the main crop and is almost all fed to live stock. Wheat is a money crop and is sold largely at local mills. Hay is consumed mostly on the farm. Oats have proved more or less a failure in recent years, and the selection of a winter variety suited to the region is suggested. Flax constitutes a minor money crop and an excellent nurse crop for grass. Kafir corn is grown as a supple-

mentary forage crop. Cowpeas are becoming more popular. White burley tobacco is grown in a limited way and there is some promise of its more extensive cultivation. Alfalfa is in the experimental stage, but the results obtained indicate that it can be grown extensively. There is but one commercial orchard in the county, though most farmers produce fruit for home consumption.

The rotation practiced in a limited way consists of corn followed by corn, oats, wheat followed by wheat, and then timothy and clover for from two to four years. Cowpeas should be introduced in the rotation whenever possible, either as a catch crop or as a main crop.

The percentage of tenanted land is increasing, and from \$2 to \$3 an acre, or two-fifths to one-half of the crops produced is ordinary rent. Land sells at \$25 to \$60 an acre.

Twelve types of soil were mapped in the county. Most of these were residual, or derived from underlying rock formation. The others were alluvial soils, forming the bottoms along the streams.

The Oswego silt loam, locally known as "white ashy land," is the predominant type, and occupies level or undulating uplands. It is well adapted to wheat, oats, and hay. The type is deficient in organic matter, and the drainage should be improved.

The Summit silt loam, called "black limestone land," is not a limestone soil, but is derived from shale. It is a typical corn soil, and wheat also yields well. The Crawford silt loam is a reddish limestone soil with good drainage. It is an excellent corn soil.

The Bates loam and Boone fine sandy loam, locally called "sandy soils," are adapted to market gardening and are so used.

The Summit clay is a heavy black soil of relative small extent and is mostly timbered.

The Bates silt loam is a brownish-gray soil with a mottled subsoil. It occurs along slopes near streams and is a good grass and general farming soil.

The Sedgewick black clay loam would be a corn soil if well drained.

The Boone silt loam is of relatively small importance, occurring as timbered land along streams.

The bottom land soils are the Osage clay and Osage silt loam. The former is a heavy black clay and, though a typical corn soil, its cultivation is largely prevented by adverse drainage conditions. The Osage silt loam is a higher-lying soil nearer the streams and is cultivated to some extent. It is recognized as producing corn of excellent feeding quality. A drainage project to drain the bottoms of the Osage River is now nearly completed, and in case it is effective about 40,000 acres of these excellent corn soils can be cultivated.

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