

Issued November 24, 1914.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

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

SOIL SURVEY OF RALLS COUNTY,
MISSOURI.

BY

A. T. SWEET, OF THE U. S. DEPARTMENT OF AGRICULTURE, AND
W. I. WATKINS, OF THE UNIVERSITY OF MISSOURI.

THOMAS D. RICE, INSPECTOR, NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1913.]



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., May 23, 1914.

SIR: I have the honor to transmit herewith the manuscript report and map covering the survey of Ralls County, Mo., and to request that they be published as advance sheets of Field Operations of the Bureau of Soils, 1913, as authorized by law.

The selection of this area was made after conference with the State officials cooperating with the bureau in the work of surveying and classifying the soils of Missouri.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

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

CONTENTS.

	Page.
SOIL SURVEY OF RALLS COUNTY, MISSOURI. By A. T. SWEET, OF THE U. S. DEPARTMENT OF AGRICULTURE. and W. I. WATKINS, OF THE UNIVERSITY OF MISSOURI.....	5
Description of the area.....	5
Climate.....	8
Agriculture.....	9
Soils.....	15
Black soils.....	19
Residual material—limestone and shale.....	19
Leslie series.....	19
Leslie clay loam.....	20
Water-laid material (recent alluvium)—mixed derivation.....	21
Wabash series.....	21
Wabash clay loam.....	21
Wabash clay.....	21
Wind-laid material—mixed derivation.....	22
Putnam series.....	22
Putnam silt loam.....	22
Brown soils.....	26
Residual material—limestone.....	26
Hagerstown series.....	26
Hagerstown clay loam.....	26
Ice-laid material—mixed derivation.....	27
Shelby series.....	27
Shelby loam.....	27
Water-laid material (recent alluvium)—mixed derivation.....	30
Genesee series.....	30
Genesee fine sandy loam.....	30
Genesee silt loam.....	31
Water-laid material (old alluvium)—mixed derivation.....	32
Jackson series.....	32
Jackson silt loam.....	33
Fox series.....	33
Fox fine sandy loam.....	33
Wind-laid material—mixed derivation.....	34
Knox series.....	34
Knox silt loam.....	35
Gray soils.....	37
Water-laid material (recent alluvium)—mixed derivation.....	37
Waverly series.....	37
Waverly fine sandy loam.....	37
Waverly silt loam.....	37
Miscellaneous materials.....	38
Rough stony land.....	38
Summary.....	40

ILLUSTRATIONS.

	FIGURE.	Page.
Fig. 1. Sketch map showing areas surveyed in Missouri.....		5
	MAP.	
4	Soil map, Ralls County sheet, Missouri.	

SOIL SURVEY OF RALLS COUNTY, MISSOURI.

By A. T. SWEET, of the United States Department of Agriculture, and W. I. WATKINS, of the University of Missouri.

DESCRIPTION OF THE AREA.

Ralls County is situated in the northeastern part of Missouri, its northeastern boundary being formed by the Mississippi River. It is bounded on the southeast by Pike County, on the south by Audrain County, on the west by Monroe and Marion Counties, and on the

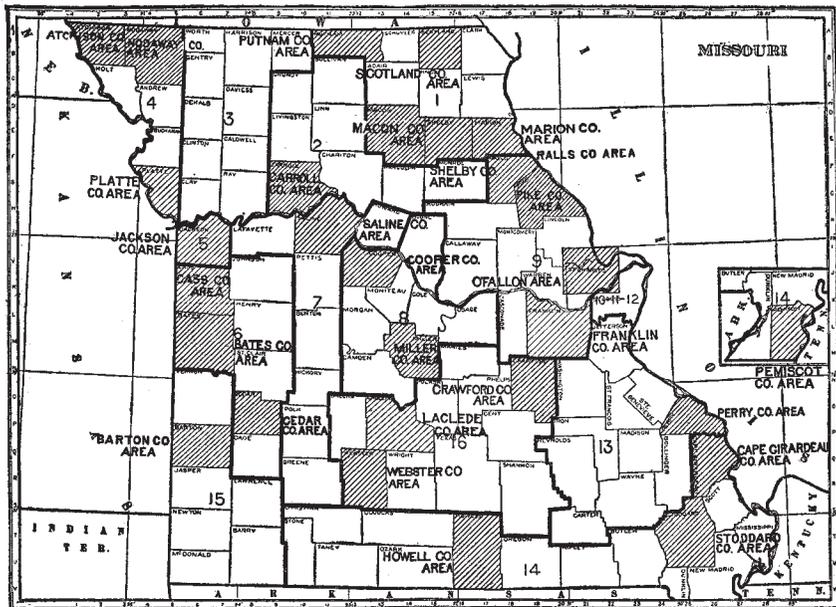


FIG. 1.—Sketch map showing areas surveyed in Missouri.

north by Marion County. It has an area of 481 square miles, or 307,840 acres.

The county comprises three distinct topographic divisions, the level or gently rolling uplands, the hilly regions, and the bottom lands or stream flood plains.

The uplands constitute much of the southern part of the county and portions of the northwestern part, and extend into the central part. The uplands region is almost level or gently sloping, and varies in elevation from about 700 to 750 feet above sea level. It attains its maximum elevation between Perry and Vandalia, in Audrain County. The edges of the upland, although very irregular, are rather sharply defined, being marked by steep slopes and in places by deep and frequently rock-bordered stream channels. In several places the edge of the upland is within less than a mile of Salt River.

It is separated into two parts by Salt River and its tributaries, the larger extending from the southern border of the county north to Perry and thence northeast to Center and New London, and the smaller from the northwest corner of the county south along the county line about half way to Salt River, and east almost to Oakwood. In the extreme eastern part of the county there is a continuation of the upland which has been cut off from the two main bodies farther west by Salt River and its small tributaries and Bear Creek. This eastern extension of the upland has been modified by erosion. It consists of narrow ridges and chains of hills which have an almost uniform elevation, and when viewed at a distance show a straight sky line similar to that of the upland region to the west.

The Mississippi River has practically no flood plain in Ralls County, the steep hills rising abruptly from the river channel. Along Salt River and Spencer Creek, however, flood plains which vary from about one-half mile to more than a mile in width are developed. Bordering the flood plains there are in places one or more well-defined benches or terraces of alluvial origin, and in some places slightly higher benches which are apparently of glacial origin. In these larger valleys there are also in many places alluvial fans or deltas, made up of material washed down by small tributary streams and deposited near the point at which they enter the broader valleys. The elevation of the more extensive flood plains is approximately 500 feet above sea level.

Between the level of the flood plains and that of the uplands proper lie the rolling and hilly regions, which comprise approximately two-thirds of the entire area of the county. The topography varies from undulating and gently rolling near the larger upland areas to hilly and very hilly near the deeper stream valleys. Along Salt River steep hills and in some places almost perpendicular bluffs occur, frequently rising to a height of over 150 feet, while in the Saverton Hills, in the eastern part of the county, very steep hills over 200 feet in elevation are encountered, although perpendicular bluffs are not so common.

Ralls County is drained almost entirely by the Salt River and its tributaries. A small area in the extreme northern part of the county is drained by tributaries of North River, South River, and Bear Creek; and another small area in the extreme northeastern part is drained directly into the Mississippi River by several small streams.

In the uplands the small streams have broad valleys which are bordered in places by slopes so gradual that it is difficult to determine where the uplands end. Good examples of this occur along Spencer Creek immediately west of Spencer Creek Church and along the upper course of Lick Creek. On passing from the upland through the heavy limestone beds to a lower level, the stream valleys become

narrower, and are shut in by high bluffs and rock-covered slopes. Upon reaching a level of softer rock beds, they again widen, and are bordered by slopes which gradually become less steep and precipitous as the lower part of the valley is reached. Many eastward or westward flowing small streams of this region have narrow flood plains on the north side, bordered by long slopes, while on the south side there are no flood plains, and the slopes are steep and often rocky.

Ralls County was first settled nearly a hundred years ago. The forested areas were settled first. The early settlers were mainly from Kentucky and Virginia, and the present population is composed largely of their descendants. During recent years, however, there has been some immigration from other parts of Missouri, Illinois, and Iowa. This has been about offset by emigration, and there has been little change in the population. The United States census for 1910 reports a population of 12,913. A slight increase over the population of 1900 is shown, but this is probably due to increase in population at Ilasco and not in rural population.

Ralls County contains no large towns. New London, the county seat, in the eastern part of the county, is the largest, with a population of about 1,000. Perry, in the western part of the county, has a population of about 900, and Center, in the central part, a population of about 600. These towns have no manufacturing interests of any kind. Coal is mined to a small extent near Perry, but with this exception the towns of the county are important only as local trading points. They are inhabited largely by retired farmers, most of whom still own their farms. At Ilasco, in the extreme northeastern corner of the county, is a large cement plant, which employs many men. Other small towns and trading points are Saverton, Rensselaer, Spalding, Huntington, Hutchison, Joanna, Madisonville, Cincinnati, Hassard, Shiel, and Nadine.

Although there are no large towns within Ralls County, Hannibal, Marion County, a city of nearly 20,000 population, is situated less than 2 miles from its northeastern corner, and Vandalia, in Audrain County, and Monroe City, in Monroe County, each having a population of nearly 2,000, are but a short distance from the southeast and northwest corners, respectively. Frankford, in Pike County, is near the eastern boundary of the county. Each of these towns draws a considerable part of its trade from Ralls County.

The county is fairly well supplied with railroad facilities. The main line of the St. Louis & Hannibal Railway, or Short Line, extends across the eastern part of the county, and a branch of this line reaches Perry, Center, and the central part of the county. The main line of the Chicago, Burlington & Quincy Railroad passes through the county along the Mississippi River, and the Chicago & Alton

Railroad touches the southeastern corner. The Missouri, Kansas & Texas Railway and the Wabash, using the track of the former line, extend almost across the county near its northern boundary, and a line of the Chicago, Burlington & Quincy crosses the northwestern corner.

Although many of the roads in the county are not in good condition, they are being rapidly improved. Good road-building material in the form of stream gravel and limestone suitable for crushing are available in the county.

Chicago and St. Louis are the principal markets for the live stock raised in the county. The feeding stock is largely from Kansas City and Omaha. Hannibal and Ilasco furnish markets for a large part of the small fruits and garden products grown in the northeastern part of the county. Hannibal is also a good market for hay, grain, and meats.

CLIMATE.

The records of the Weather Bureau station at Hannibal, Marion County, are fairly representative of the climatic conditions in Ralls County. The following table gives the normal monthly, seasonal, and annual temperature and precipitation recorded at this station:

Normal monthly, seasonal, and annual temperature and precipitation at Hannibal, Marion County, Mo.

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.....	31.3	69	-18	1.09	0.95	1.12
January.....	26.7	71	-15	1.76	1.40	3.64
February.....	29.1	69	-25	1.78	1.80	1.60
Winter.....	29.0			4.63	4.15	6.36
March.....	41.6	91	0	2.52	1.00	6.41
April.....	53.6	90	19	2.77	1.20	3.48
May.....	64.4	91	30	4.67	4.70	6.90
Spring.....	53.2			9.96	6.90	16.79
June.....	73.3	100	43	4.06	2.10	4.83
July.....	77.4	108	47	3.46	1.00	4.20
August.....	75.0	100	47	2.98	1.20	1.05
Summer.....	75.2			10.50	4.30	10.08
September.....	67.9	101	32	3.13	.70	8.86
October.....	55.9	91	22	2.38	1.20	2.94
November.....	40.5	78	4	1.90	1.10	2.58
Fall.....	54.8			7.41	3.00	14.38
Year.....	53.1	108	-25	32.50	18.35	47.61

The annual temperature averages about 53° F. The lowest temperature recorded at Hannibal is -25° and the highest 108°. Such extremes are rare, although there are frequent abrupt changes, especially during the spring and fall months, which may result in injury to crops. Extremely heavy rainfalls and droughts are uncommon.

There is an average annual rainfall of about 33 inches. This is well distributed throughout the year, the greatest precipitation occurring during the months of May, June, and July, when it is most needed, and the least during the month of December. The rainfall is adequate to insure good crops where proper steps are taken to conserve the water in the soil.

The average date of the last killing frost in the spring is April 14, and of the first in the fall October 15, giving an average growing season of about 6 months. The latest date of killing frost recorded is May 14, and the earliest date recorded September 30. There is ample time for the maturity of all ordinary farm crops, for growing cowpeas following wheat, oats cut green for hay, or early potatoes, for harvesting three crops of alfalfa, or for growing two or more crops of certain vegetables. The late falls, with abundant rain, are favorable to the growth of bluegrass in pastures, so that it is frequently unnecessary to commence feeding stock before the first or possibly the middle of November. During the early spring fruit prospects are frequently injured by periods of warm weather followed by freezing weather. Heavy rainfall in the spring, which renders the soil compact, is sometimes followed by a period of dry weather, which causes it to bake and crack and become hard and cloddy. Hot, dry winds from the west occasionally result in injury to corn and other crops, and the frequent freezing and thawing of the ground during the late winter and early spring result in "heaving," causing injury to wheat and clover.

AGRICULTURE.

The soils and climate of Ralls County are well suited to the type of agriculture commonly practiced. This consists of stock raising combined with grain farming, supplemented by dairying, poultry raising, gardening, and the growing of apples and small fruits.

The early settlers located on the lower hill lands near the streams, where the soils were fertile and water, wood, and game were abundant. Only the cleared and cultivated fields were fenced, leaving an open range for stock. Cattle raising proved profitable, and in a short time large herds were grazed upon the prairies each spring. The cattle were cared for by herders until the fall, when the fattened animals were driven to market, the younger cattle being kept for the next year. The open range gradually became poorer, and in time large tracts were bought at a low price and fenced for pasture. Close

grazing resulted in the killing out of the native blue-stem grass, but this was quickly succeeded by bluegrass, and there are yet in Ralls County a few remnants of these old pastures which have never been under cultivation, and many others have been cultivated only within the last few years. The closing of the range, the division of the land formerly used as pastures into smaller holdings, and the gradual extension of grain farming into the prairie sections have resulted in a type of general farming and stock raising over a large part of the county in which stock raising is the predominant feature. In the longer settled parts of the county, especially in those in which there is a considerable mixture of limestone and loess soils, grain farming is also combined with stock raising, the grain growing being most important, and wheat in places being the principal money crop.

In the grain-growing regions the soil, which is naturally productive, is, through continuous cropping, slowly becoming less so. There is little change in farm methods and abandoned farmhouses and neglected improvements in many places indicate a poor agricultural condition. On the other hand, on the more recently settled lands, through the growing and feeding of live stock, the rotation of crops, and the use of better general farming methods, the soils are being built up and made more productive. Large and well-kept houses and barns, silos, and concrete water tanks, with manure spreaders and other improved implements commonly seen in the prairie sections, are indicative of progress. In general, throughout the county, however, farm improvement is receiving increasing attention.

The principal farm crops grown are corn, wheat, clover, timothy, and oats. Cowpeas, millet, alfalfa, redtop, and sorghum are also important.

In 1912 there were 64,641 acres devoted to corn in Ralls County, and the average yield was 32 bushels per acre, which is practically the average yield for the entire State. The best corn soils of the county are found in the bottom lands, principally along Salt River, with the better hill soils in which there is a high percentage of limestone and loess, and the well-drained soils of other areas. On such soils yields of 40 to over 60 bushels per acre are common.

In the prairie soil the change in color from dark gray in the surface section to light gray in the underlying material practically marks the depth of cultivation. Very deep plowing or subsoiling, which brings large quantities of the light-gray silt or heavy clay to the surface at one time, results in diminished yields, but the gradual increase of the depth of plowing, with incorporation of large quantities of manure, green clover, or cowpeas into the soil, avoids these diminished yields and permanently improves the soil. Such treatment also increases the water-holding capacity of the soil.

The sandy prairie border soils and the white post-oak ridges are not so well suited to corn as the darker soils, but produce good yields where proper methods are employed.

The leading variety of corn in the upland is Reid's Yellow Dent. In the bottoms Boone County White is the most popular variety. Other varieties grown are Johnson County White, Long John, and Iowa Silver Mine. The improvement of the crop through seed selection is receiving the attention of many farmers in the county.

In 1911 wheat was grown on 18,806 acres in Ralls County, with an average yield of 14 bushels per acre. This is somewhat less than the average yield for the northeast section of the State, the difference being due mainly to the large area of eroded prairie border and leached ridge soils used.

The soils best adapted to wheat are those in the central and eastern parts of the county, where a large part of the soil is of limestone origin or where there is a thin surface layer of silt. Some of the best of these soils are included in the "elm-woods lands." In these areas wheat has been grown since the county was first settled, and on many of the fields it is grown almost continuously. As a result the soil has deteriorated and yields have decreased. For many years no commercial fertilizers were used, but in recent years their use has been found necessary in order to insure good yields. Although the average yield for the county is low, yields of 25 to over 30 bushels are common on the better soils, and many farmers report an average of 18 to 20 bushels or more for a period of several years.

For many years wheat was grown on the prairie soils to only a small extent. During the last 10 or 15 years, however, the acreage has been extended, and through the use of commercial fertilizers yields practically as large as those in the eastern part of the county are obtained.

In Ralls County wheat is sown following oats or corn. It is sometimes drilled between the corn rows before the corn is cut. The most popular variety is the Fultz. The Red Chaff, Red Cross, May Queen, and some other varieties are also grown. In experiments at the Missouri Agricultural Experiment Station several varieties of soft wheat were found to give a better average yield for a period of 5 years than the Fultz. These were the Michigan Wonder, Jones Red Wave, Hickman, Beechwood Hybrid, Dawsons Golden Chaff, Early Ripe, and Poole. Of bearded wheats Dietz, Rudy, Mediterranean, Fulcaster, and Lebanon gave the best results.¹

Next to corn and wheat the most important crop of the county is clover. It is of value as a hay and forage crop and for its seed,

¹ "Some Factors in Wheat Production," Circular No. 56, Missouri College of Agriculture, Columbia, Mo.

but is of even greater value for its beneficial effects upon the soil. Clover does best on a rich soil which has a deep, well-drained subsoil and is not acid. In Ralls County the best wheat soils and the better drained bottom-land soils are best adapted to clover. However, with the exception of small areas of poorly drained soils, mainly in the prairie, clover can be grown with some success in all parts of the county. On types having a poorly drained subsoil the "heave" of the soil during the freezing and thawing of early spring injures the clover. Such soils are also invariably strongly acid, a condition very unfavorable for clover. Clover yields from 1 to over $2\frac{1}{2}$ tons of hay per acre annually, depending on the season. Under favorable seasonal conditions two cuttings are obtained. Where thrashed for the seed, from $1\frac{1}{2}$ to as much as 4 or 5 bushels per acre is secured.

Next to clover the most valuable legume crop in this region is cowpeas. This crop may be grown on thin soils and on soils too acid for clover. The principal objections to the crop are the cost of seed and the difficulty of obtaining a stand and of properly curing the hay. Where grown extensively, as is usually done on the better soils, they produce much vine, but little seed. On the poorer and eroded soils they make little vine, but produce much seed, and the seed crop is profitable. Better methods of handling and curing the hay are being developed as the acreage is extended.

In this region, if wheat is cut early and the ground immediately disked cowpeas may sometimes follow the same year, or they may be grown after oats when this crop is cut in the milk for hay. They may also be planted in the corn at the last cultivation or in the hill or drill at the time the corn is planted, the latter method being preferred.

Considerable attention is being given to the growing of alfalfa. In several places, especially in the vicinity of New London, small areas have been sown to this crop, and some farmers are increasing the acreage devoted to it.

A deep, well-drained, sweet soil, such as is necessary for the best development of clover, is required for alfalfa. Owing to its deeper rooting and longer life it is even more exacting than clover in this respect. Experiments throughout Missouri and Iowa indicate that on the upland prairie, like that in Ralls County, there is only a very slight chance of success in growing alfalfa, because the soil does not meet these requirements. The soils in Ralls County best suited to alfalfa are the deep, well-drained, dark-colored silt loams and fine sandy loams in the valleys of the larger streams. These soils have the very serious objection of being subject to overflow, which may result in the loss of a single crop or even in the killing of the plants. The best wheat and clover upland soils and the small areas of deep,

well-drained bottom soils not subject to overflow, or overflowed for but brief intervals, offer the best opportunities for growing alfalfa. Next to these areas, the narrow strips of wash in the small stream bottoms and the sandy prairie border soils are best suited to the crop.

One other crop which deserves attention, although not grown on a commercial scale in the county, is tobacco. Before the Civil War this crop was grown in Ralls County to a considerable extent, and fair yields of tobacco of good quality were obtained. In Pike County, adjoining Ralls County, on soils identical with those of large areas in Ralls County, tobacco is now grown quite extensively and profitably. The White Burley is the principal variety, and yields of from 1,200 to 1,800 pounds of tobacco of good quality are obtained. The best clover and wheat soils in the central part of the county and the high, loess-covered hills in the extreme eastern sections would probably give good yields of tobacco.

In several counties of the State bluegrass seed in large quantities is harvested for the market. The machinery for collecting the seed is inexpensive, little labor is necessary, and the pastures are not injured. This industry offers excellent opportunities in Ralls County.

Much waste land now grown up with scrubby white oak and post oak would, if cleared, make fair pasture land. The method commonly used for clearing such land is to remove the timber and then pasture goats on the land so that it may be grazed closely until the sprouts are killed. Since the bluegrass makes a natural growth and spreads rapidly as the timber is killed out, no seeding is necessary.

The use of commercial fertilizers is receiving increasing attention in Ralls County. Fertilizers were first used on wheat, later on oats, and they are now being used to a small extent on corn. The Missouri Agricultural Experiment Station has made certain recommendations with respect to the use of commercial fertilizers which are directly applicable to this region. For wheat on badly worn lands a complete fertilizer containing from $1\frac{1}{2}$ to $2\frac{1}{2}$ per cent of nitrogen, from 8 to 12 per cent available phosphoric acid, and from 2 to 3 per cent potash, applied at the rate of 100 to 150 pounds per acre at the time the wheat is sown has proved effective, and on lands fairly well supplied with humus 125 to 150 pounds of steamed bone meal of good grade is beneficial. For corn on medium to poor lands 60 to 75 pounds of the same grade of complete fertilizer recommended for wheat may be applied in the hill or drill with a fertilizer attachment. An application of more than 75 pounds may cause firing in case of drought.¹

The acidity of the soil is an important question to which farmers of this county have given but little attention. Numerous tests with litmus paper made during the progress of the soil survey indicate

¹ Press notice, Missouri Experiment Station.

that all prairie soils, all white ridge soils, and many poorly drained bench and bottom-land soils, especially those forested with water oak and post oak, are deficient in lime. The prairie border soils and even the heavy loess soils were sometimes found to be deficient, but apparently to a somewhat less extent. The soils in the county which do not show a low lime content are some of the recently deposited bottom soils and narrow strips immediately below and in some cases above outcrops of limestone. Even the bright-red soils forested with walnut are deficient in places, owing to the leaching out of the lime. This deficiency can be corrected by the use of lime or ground limestone, the latter in most cases being preferable because it is less expensive and because its effect, although slower, continues for a longer time. The prairie soils probably require from 1 to 2 tons of limestone to the acre once every six or eight years, and the hill soils a somewhat smaller amount. Finely ground limestone of a high grade can be obtained cheaply in carload lots from several companies in Missouri. Several beds of limestone of good quality occur in Ralls County. One or more of these beds outcrop along almost every small stream. Rock from these beds might be crushed and utilized in agriculture.

The crop rotations most commonly used in Ralls County are corn, oats, wheat, clover; corn, wheat, clover; and corn, oats, timothy pasture. The corn is planted for two or three years in succession and in some cases wheat follows wheat for two years or more. The rotation in which oats and timothy follow corn is used principally in those sections in which clover does not do well. On the prairie, too, it is often the custom to use the land for pasture for several years, then turn the bluegrass sod and plant to corn continuously for several years. The most serious hindrance to maintaining a good crop rotation is the difficulty of obtaining a stand of clover or timothy when seasons are unfavorable, and of growing clover at all in some sections.

The loss of soil caused by erosion is but little appreciated by most farmers. It is one of the most serious losses to which the soils are subject. When it is remembered that all of the hills in the county are the result of this process, that the cutting of rivers, creeks, branches, and gullies, and the wearing down of the hills have changed an almost level surface into its present form, the extent of erosion working through long periods of time can be realized. This process is going on at present, however, faster than before, because it is aided by the removal of the trees, the breaking of the sod, and the starting of numerous gullies down corn rows, in dead furrows, and at the roadsides. The cutting of deep gullies is checked by the best farmers, but the more serious sheet erosion which removes the best soil from the entire surface, leaving "clay points" and "gall spots," is often unnoticed.

The first and most important step toward counteracting erosion is the formation of an ample soil reservoir to absorb and retain large quantities of rain water and thus prevent rapid run-off. This can be accomplished by incorporating organic matter, by deeper plowing, and by growing deep-rooting crops. On the steeper slopes the soil can be protected during the winter with a crop of wheat or rye, or it can be used for permanent pasture.

The question of drainage receives little attention in this county. On the uplands there are areas along nearly all of the divides which are capable of being greatly improved by artificial drainage. The principal areas of this kind form the divides between Spencer Creek and Lick Creek, and between the streams which drain the extreme northern part of the county and the southward flowing tributaries of Salt River. To drain these areas of flat prairie properly it is necessary to construct open ditches, and to cultivate the land so that surplus water from the entire field will drain into them. Experiments by the Missouri Experiment Station on this kind of soil at Vandalia indicate that where an outlet can be obtained tile drainage is profitable. Many areas on the hill slopes which are kept saturated by seepage and other poorly drained areas in the bottoms if tile drained would undoubtedly give much larger and more certain yields.

Although modern methods of agriculture are practiced by many progressive farmers throughout Ralls County, there is room for improvement in many directions.

The high price of cattle during the last few years and scarcity of feed during the years 1911 and 1913 have resulted in reducing the number of cattle far below normal. The interest in dairying and the attempts of many farmers to build up dairy herds from low-grade scrub stock have resulted in a very undesirable mixing of types. One of the most serious needs of Ralls County at present is an increase in the number and an improvement in the grade of live stock of all kinds. There is a general need in Ralls County for the more extensive growing of clover and cowpeas, the more careful and liberal use of manure and of green fertilizers, the application of lime, deeper plowing followed by more persistent surface cultivation, to collect and hold moisture, and the intelligent use of commercial fertilizers.

SOILS.

The soils of Ralls County may be separated according to origin into four broad classes or divisions. These are the residual soils, the glacial soils, the loessial soils, and the alluvial soils.

The geology of this region is comparatively simple and easily understood. Along Salt River and all of the other large streams of the county are horizontal or nearly horizontal rock beds. In passing

downstream or to a lower level underlying beds of a different formation are encountered, and in passing upstream higher lying beds of other rocks are found. The lowest or oldest of these beds are exposed in the central and southeastern parts of the county, and the highest or youngest in the southwestern and northwestern sections.

The lowest of these rock formations is the Trenton limestone, almost perpendicular bluffs of which border the valley of Salt River on one side or the other almost entirely across the county. Where the Trenton limestone is exposed on the hill slopes it has a peculiar form of weathering by which it may easily be recognized. Large, irregular, and winding holes or canals having somewhat the appearance of wormholes extend through the fragments. Slopes on which the Trenton limestone is exposed are common in the vicinity of New London, Spalding, and many other places. The sinks or sink holes so common in many parts of the county usually occur where this formation is near the surface.

The Trenton limestone is overlain by a thick bed of light-blue to gray shale, known as the Hudson River shale. Above this shale there is a massive bed of yellowish-brown soft limestone, known as the Niagara limestone. This formation seems to be much thinner and less conspicuous in Ralls County than farther south in Pike County. Above the Niagara limestone a rather thin bed of dark-colored, rather hard shale is developed, and above this a bed of almost white, fine-grained, thin-bedded limestone called the Louisiana limestone. Above the Louisiana limestone occurs the Hannibal shale, consisting of a thick bed of bluish argillaceous shale, the top layer of which is often sandy and in places a yellowish-brown, soft sandstone. Above the Hannibal shale are three beds of limestone, the Chouteau, Burlington, and Keokuk, between the thin beds of which are numerous lenses of chert or flint.

In the western part of the county, especially along the upper course of Lick Creek, are thin alternating beds of soft limestone and black, purplish, or drab shale. These formations belong to the Coal Measures, and are the only beds which do not occur in the eastern sections of the county. In several places in the central and western parts of the county sandstone beds which vary from a few inches to several feet in thickness outcrop. The lowest of these are believed to be sandy lenses in the Hudson River shale, while the higher is thought to be the upper part of the Hannibal shale. It will be noted that the rock beds of the county consist of hard beds of limestone and alternating soft beds of shale.

The three upper flinty limestone beds—the Keokuk, Burlington, and Choteau—underlie the prairie region and all of the hills in the county. Where these resist erosion the topography is level or gently rolling, but where erosion is active it is steep and broken, and frag-

ments of limestone and chert are scattered over the surface. Streams which on the uplands are wide and shallow pass through these formations in deep, narrow, rocky valleys. Below the horizon of the resistant limestone beds the slopes are more gradual and the stream valleys wider. Owing to the thinness of the Niagara and Louisiana limestone beds, these formations have much less influence on the topography than have the higher cherty beds, but in places they, too, are responsible for steep slopes. Owing to its great thickness and massive structure the Trenton limestone stands up in perpendicular or overhanging bluffs where cut into by streams, but where it is not badly eroded it weathers out into broad valleys. Both the shale and limestone beds of the Coal Measures are soft and weather rapidly, the resulting broad, shallow valleys being well illustrated by the upper valley of Lick Creek, south of Perry. Shale beds of a thickness almost as great as that of the limestone occur throughout the county, but owing to the more gradual slopes into which the shale weathers and the surface covering of soil they are rarely seen, except on very steep slopes or where cut into by streams.

Although limestone beds are quite conspicuous through much of the hilly part of the county and a large part of the soils has come from the disintegration and erosion of limestone and shale, only a few of the soils of the county are purely residual, because most of the residual material has been mixed with or covered by other material.

At the horizon of the Trenton and Louisiana limestone beds and in places immediately above outcrops of these formations a bright-red, dark-red, and in some places a very black soil occurs which is largely residual from these formations. In the western part of the county, where Lick Creek and its tributaries have cut into the Coal Measure shale beds, a black heavy residual shale soil is recognized as the Leslie clay loam. A few small areas of heavy soils from other shale beds are correlated with this type. The Rough stony land may also be classed with the residual soils.

In nearly all parts of Ralls County well-rounded bowlders, pebbles, and gravel of quartz, granite, quartzite, greenstone, and other rocks entirely different from local formations are encountered. There are no outcrops of such rocks farther south than Wisconsin, and some of the fragments found in Ralls County are from regions much farther north. These erratics, or "lost rocks," as they are sometimes called in this region, were transported by continental glaciers which at one time extended southward to the Missouri and Ohio Rivers. As this ice sheet pushed farther south it not only carried this hard foreign material, but also large quantities of clay resulting from the grinding up of soft local limestone and shale. This material was deposited when the ice melted and constitutes

the glacial drift. It is estimated that as high as 90 per cent of the drift in Missouri is of local origin, from the limestones and shales within the State.¹ Evidences of the almost complete glaciation of Ralls County are abundant. In the extreme eastern part of the county erosion near the hilltops reveals beds of sandy clay and water-worn gravel. The same material is encountered along the slopes bordering nearly all of the small streams, under the dark-colored prairie soil, along the edge of some of the higher terraces in Salt River Valley, mixed with chert on the rocky slopes, and often quite close to limestone bluffs and outcrops. On the level upland it has been found in digging wells that this glacial deposit varies in depth from a few feet to 50 feet or more. In most places it has completely or almost completely covered the underlying residual soils. In general, the glacial soils of the county, although having considerable variation, are mapped as the Shelby loam.

On the uplands adjacent to the flood plains of the Missouri and Mississippi Rivers there is a silty material usually called loess. It occurs on the tops and slopes of the hills and in the valleys, regardless of topography, in long, narrow strips parallel to the flood plain, being thickest on the river side and becoming thinner with increase in distance from the river. The coarser material occurs near the river, while the finer silt and clay are found farther away. This material along the Mississippi differs from that along the Missouri in having less depth and a higher percentage of clay. The dark-colored prairie soil and the light-gray upland ridge soils seem to be partly glacial and partly derived from this silty deposit. The subsoil is glacial, glacial till and erratics being exposed wherever a well or pond is sunk to a depth of a few feet or where a ditch or gully cuts through the surface soil. The surface soil consists of a fine silty material resembling the river loess in texture, but its source is not definitely known by geologists. The darker colored prairie soils are classed as the Putnam silt loam and the ridge soils as the light-colored phase of that type.

Closely related to the upland prairie soil is a type known locally as "crab-apple land." This soil occurs in small areas along the outer edge of the valley of Salt River and in a few other places. It has the same arrangement of soil layers found in the Putnam silt loam, and is underlain by glacial till. It appears to be a glacial deposit in a preglacial valley which is again partly occupied by a stream valley. The soil, although not identical with this type as it has been described in other areas, is mapped as the Jackson silt loam.

The alluvial soils are made up of material eroded from other soils of the county, carried by water in suspension, and redeposited. They

¹ Emerson, *Geography of Missouri*, University of Missouri, Bulletin, Vol. I, No. 4.

vary widely in character, depending upon the source from which they are derived, the method of deposition, and the changes they have undergone since being deposited. A large part of the light-gray soil in the bottoms is no doubt derived from the gray layer of the prairie soils and from the gray forested ridges. The sandy bottom soils are derived largely from the sandy glacial upland soils. The residual limestone and shale soils and the loess soils have also contributed material to form the alluvial soils.

Closely related to the alluvial soils are those soils found in the valleys of the small streams, at the foot of the steep slopes which border the wider valleys, and wherever conditions have been favorable for the accumulation of soil material. This soil was not carried in suspension by streams, but has reached its present position through the gradual wash of surface water, the force of gravity, the gradual movement due to cultivation, the trampling of stock, and the movement of soil particles by the wind. Such drift, or creep, often results in almost flat areas of dark-colored soil, frequently resembling in appearance and in crop value the true alluvial types. Where of sufficient size, these areas are classed with the alluvial soils.

The alluvial soils in Ralls County are grouped in three soil series. The dark, heavy soils are mapped as Wabash; the recent fine sandy and silty dark-gray soils as Genesee; and the light-gray or almost white soils as Waverly. The wash has been included as a colluvial phase of the Genesee silt loam.

The following table gives the names and the actual and relative extent of the soils mapped in Ralls County:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Putnam silt loam.....	106,880	} 36.0	Hagerstown clay loam.....	4,480	1.5
Light-colored phase.....	4,032		Genesee fine sandy loam.....	3,008	1.0
Shelby loam.....	95,360	31.0	Leslie clay loam.....	2,112	.7
Rough stony land.....	39,296	12.8	Jackson silt loam.....	1,664	.5
Genesee silt loam.....	14,912	} 9.0	Wabash clay loam.....	384	.1
Colluvial phase.....	12,992		Waverly fine sandy loam.....	384	.1
Knox silt loam.....	384	} 5.5	Wabash clay.....	256	.1
Heavy subsoil phase.....	16,512		Fox fine sandy loam.....	256	.1
Waverly silt loam.....	4,288	} 1.6	Total.....	307,840
Heavy phase.....	640				

BLACK SOILS.

RESIDUAL MATERIAL—LIMESTONE AND SHALE.

LESLIE SERIES.

The surface soils of the types in the Leslie series are black. The subsoils consist of dark-gray or mottled, compact, tough clay, and are underlain by alternating beds of limestone and black fissile shale,

from which the soils of the series are derived as a residual product. Fragments of limestone and shale are generally present in the soil and subsoil. The topography varies from steep to rolling.

LESLIE CLAY LOAM.

The Leslie clay loam is a dark-gray to black heavy clay loam, which at about 10 inches grades into a black heavy, tenacious clay. At a depth of about 18 inches this is underlain by a mottled yellow and gray stiff, tenacious silty clay, which extends to a depth of 3 feet or is at a less depth underlain by shale. The type in many places contains in both soil and subsoil numerous fragments of soft limestone and shale, these in places being so abundant as to interfere with cultivation.

Along the edge of Spencer Creek bottom near Mud Lick School two small areas of soil derived largely from one of the lower shale beds is correlated with this type. Along the edge of the bottoms of Salt River and Spencer Creek and their larger tributaries there are many places where the streams have cut back into shale beds and formed small areas of residual or partly residual shale soil. On the hill slopes also, especially where the Hudson River shale occurs beneath the Niagara limestone and the Hamilton shale below the Louisiana limestone, there are many small areas of residual shale soil which should properly be correlated with this type, but which, owing to their small size, can not be mapped separately and are included with the surrounding soils. Some of these areas, on account of the steep slopes on which they occur, are included with the Rough stony land.

Some areas of the Leslie clay loam, especially where they extend down into the bottoms and are partly alluvial or colluvial, resemble the Wabash clay loam very closely both in appearance and in crop value.

The Leslie clay loam bakes and cracks when dry and is difficult to cultivate, except when in just the proper moisture condition. Where the surface covering of lighter soil is of sufficient depth and the soil is well managed, it is a strong, productive soil and produces good yields of corn.

The results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Leslie clay loam are given in the following table:

Mechanical analyses of Leslie clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
343205.....	Soil.....	0.2	1.0	0.9	2.3	5.4	54.5	35.9
343206.....	Subsoil.....	.8	1.5	1.1	1.9	2.9	47.9	44.1
343207.....	Lower subsoil...	.7	1.2	.8	1.6	2.6	45.2	47.8

WATER-LAID MATERIAL (RECENT ALLUVIUM)—MIXED DERIVATION.

WABASH SERIES.

The Wabash soils are prevailing black, ranging to dark brown, and contain a high percentage of organic matter. The subsoils are drab or gray. These soils are developed in the first bottoms of streams in the Central Prairie States. They extend for long distances along the Mississippi River. The material is derived principally from the loessial and associated soils of the region.

WABASH CLAY LOAM.

The Wabash clay loam in Ralls County is a very dark gray, almost black soil, ranging in texture at the surface from a light loam to clay loam, and becoming heavier with increasing depth. At depths varying from 3 to 8 inches it grades into a black heavy clay loam, and this is underlain at about 15 inches by a black heavy, tenacious clay. Below 24 inches the clay subsoil is somewhat lighter in color, continuing as a bluish-gray plastic clay to a depth of 3 feet or more.

There is only one typical area of this soil in the county. This area lies in Spencer Creek bottom between Madisonville and Seely Schools. Many small areas in which the soil closely corresponds with the Wabash clay loam are included with the Genesee silt loam.

This soil is alluvial in origin, and is subject to overflow. It is in need of surface and tile drainage, and the texture can be improved through the incorporation of organic matter.

Where the lighter textured surface soil is of good depth and the soil is well drained, this is one of the most productive and durable soils in the county. It is particularly adapted to corn and clover. Where the loose surface covering has a depth of only a few inches, the soil is difficult to cultivate except under very favorable moisture conditions. In dry weather injury is caused by the drying out and checking of the heavy subsoil.

WABASH CLAY.

The surface soil of the Wabash clay is very dark gray to bluish black. It is heavy and tenacious and difficult to handle. The type is usually poorly drained, and upon drying the soil bakes and cracks. The subsoil below 15 inches is lighter in color, but is heavy and impervious.

The Wabash clay is an alluvial soil, yet in certain areas in Ralls County it is apparently related to adjoining areas of black shale which have been cut into and partly eroded by streams. It is developed only in a few small areas in this county.

This type is in need of tile drainage, the plowing under of green crops, and the application of manure and lime.

WIND-LAID MATERIAL—MIXED DERIVATION.

PUTNAM SERIES.

The soils of the Putnam series are black, ranging to dark gray. The subsoils are composed of drab or brown fine-textured, close-structured material, and are practically impervious. The presence of a whitish layer of silty material between the soil and subsoil is characteristic of the series. The soils occupy level to gently undulating upland prairies and are derived from silty deposits. Owing to the level topography and the dense structure of the subsoil, drainage is generally poor. These soils differ from the Shelby soils in containing little or no glacial till, although this usually underlies the Putnam soils at variable depths. Consequently little of the soil of this series is coarser than a silt loam. This series was established to include the soil previously classified as the Shelby silt loam, but differing from the other Shelby soils in being derived entirely from loess.

PUTNAM SILT LOAM.

The soil of the Putnam silt loam has a gray to light-gray color when dry, but when moist it is gray to dark gray and in places almost black. The surface soil is prevailingly a silt loam. It ranges in texture from a very fine sandy loam to a silt loam, and becomes slightly heavier with increasing depth. At about 6 to 9 inches, which is usually the maximum depth of cultivation, faint mottlings of gray appear. This color increases until at about 12 inches the soil is a light ashy gray. This layer of grayish material is in some places heavier and more sticky than the surface soil, but as a rule it has the appearance of an almost pure silt. It frequently contains, especially in the lower part, numerous small iron concretions varying from the size of a pinhead to that of a pea. At a depth of 16 to about 20 inches the gray layer is underlain by a heavy, stiff, impervious clay, brown, dark brown, reddish brown, or mottled gray and brown in color. This clay extends to a depth of 24 to 30 inches and grades into mottled yellowish and gray material, more silty and much more friable and pervious than the clay. These layers, although differing in thickness, are invariably encountered in this type, in the order given. In road cuts or where gullies have cut perpendicular banks the thin layers, owing to their difference in color, give the walls a banded appearance.

Although this type is fairly uniform throughout the county, there are some variations. In the more undulating areas the surface soil is slightly deeper, the gray layer less distinctly marked, and the clay layer somewhat thinner and less impervious than in the more nearly level and poorly drained areas. The clay layer, especially near the

boundary of the Shelby loam, often has a reddish-brown color. In the flat, poorly drained areas the gray layer is often quite near the surface, and in some places the dark surface layer is almost entirely absent. A good example of this may be seen on the divide between South River and Cedar Creek a mile southeast of Huntington. Here the surface soil is light gray, and there is little change in color or texture to a depth of about 18 inches, below which a very dark colored, heavy clay is encountered. This extends to a depth of 3 feet with little change in color and texture. Formerly this divide was partly forested with water oak, and the soil is said to have been rather unproductive.

In several places along the strip of Putnam silt loam which extends west from Oceanwave Church, and also between Rensselaer and Spalding, there are small areas which closely approach the Marshall silt loam, although this type is not recognized in Ralls County. These areas were formerly forested. They are spoken of locally as "elmwood lands," and are noted for their productiveness. In these areas the surface soil is somewhat darker than the typical Putnam, the gray layer is less sharply marked, and the clay layer, which is drab or slightly mottled with gray, does not give place within 36 inches to the more silty layer, but continues with about the same color and texture to a depth of 3 feet or more.

Two miles southeast of Rensselaer a small area of upland soil known as "elmwood land" is correlated with the Putnam silt loam, as it seems to be of the same origin. Around the heads of small streams fragments of limestone are common and in many places the soil overlying the limestone is not more than a few feet in depth. In a cross section, however, the subsoil is seen to be made up of glacial material and to contain large quantities of sand, a few water-worn gravel, and fragments of chert. The soil is a dark-gray, almost black, silt loam of light texture. At 15 inches slight mottlings of gray occur, and the material becomes slightly heavier. Below 21 inches the soil grades into a clay loam or clay which is much lighter and more pervious than the clay layer of the typical Putnam. The subsoil becomes slightly lighter with increasing depth. This area differs from the greater part of the type in having a darker surface, the gray layer less sharply defined, and a lighter and more pervious clay layer. It is also more productive and more durable, and was originally forested with large elms.

The greater part of the Putnam silt loam occurs in two continuous bodies, separated by Salt River and the adjoining hilly region. The larger of these areas extends from the southern boundary of the county northward between Spencer Creek and Lick Creek to within a mile of Salt River, and then swings northeast, forming the divide

between Salt River and Spencer Creek to New London. Branches of this main body finger out along the divides between the small tributaries of Spencer Creek, Lick Creek, and Salt River. The smaller area extends from the northwestern corner of the county, eastward almost to the Hannibal and New London gravel road, and southward to within about 2 miles of the river. Extensions from the main body occupy the crests of the ridges between the tributaries of Salt River from the north. There are also a few small outlying areas. The type thus occupies practically all of that region described as the level upland.

The elevation of this upland varies from about 700 to 750 feet above sea level, and the surface is almost level to gently rolling. The topography of the typical Putnam silt loam when it occurs on the broad divides is of smoother character. Although the edges of the areas are very irregular in outline they are sharp and clearly defined, being marked by the more rolling topography and the change in the color of the surface soil from dark gray to the brown or yellowish brown of the Shelby loam.

The Putnam silt loam is of doubtful origin. The most probable theory is that the silty surface soil has weathered from a thin mantle of loess and the heavy subsoil from the underlying glacial till. It is not conceded, however, by many geologists that the surface covering is loess. Whatever the source of the original material, the impervious subsoil and the nearly level topography have resulted in the weathering of the soil under conditions of imperfect drainage.

This type, owing to its extent, its crop-producing value, and its high state of development, is the most important soil type of the county. Small areas of other types may produce larger yields of certain crops, but owing to their uneven topography, their limited extent, or their liability to overflow they are less desirable for farming on a large scale. All of the Putnam silt loam is under cultivation and the greater part of it is well improved. Originally, the soil was well supplied with nitrogen, but in many cases this has been seriously depleted by constant cropping to corn. Better methods, however, are now being followed, and crop yields are increasing. Corn yields vary widely, depending upon previous treatment of the soil, methods of cultivation, and the season. The average yield for the better part of the type under favorable conditions is probably almost 40 bushels per acre, although much larger yields are obtained and smaller yields are common.

Wheat was not grown to any considerable extent on this type until within recent years. Through the use of commercial fertilizers yields about as large as those from the hill soils are obtained. The yields range from about 12 to 25 bushels, with an average of about

16 bushels. The Putnam silt loam is well suited to corn, oats, timothy, redtop, sorghum, bluegrass, and cowpeas. In the more rolling and better drained areas clover does fairly well. It is not well suited to alfalfa nor to fruit trees. It has no hardpan, but the impervious clay layer restricts drainage. The type is uniformly acid. It is in need of lime and thorough surface drainage.

The Putnam silt loam occupies what was originally, with a few exceptions, prairie land, overgrown with native grasses, while the adjoining lands were forested. Since it has been cultivated, however, some trees have gained a foothold in the prairie and seem to thrive. The most common of these are wild cherry, elm, hackberry, honey locust, and laurel oak.

Putnam silt loam, light colored phase.—The light colored phase of the Putnam silt loam is closely related to the typical Putnam silt loam in origin, but differs somewhat from it in appearance and in crop value. The soil is a light-gray, almost white silt loam which is underlain at depths varying from 10 to 16 inches by a stiff, impervious, tenacious clay, which is yellow, yellowish brown, or a faintly mottled yellow and gray in color. Below 30 inches, like the typical Putnam silt loam, the material is slightly lighter in texture and more friable. On the surface and scattered through the surface soil are small iron concretions or buckshot, and in many places the lower part of the surface soil has a yellowish or buff color. In places this phase is closely associated with the silty phases of the Shelby loam and in the eastern part of the county the thorough leaching of the surface covering of silt has produced a soil almost identical in appearance with, but apparently somewhat more productive than, the Shelby. Tests with litmus paper indicate that this phase is strongly acid, the acidity apparently being even greater than in the typical Putnam silt loam.

This soil occurs at about the same elevation as the typical Putnam silt loam or slightly lower, and is confined to narrow ridges, projecting points, and narrow rims bordering the upland. These areas may at one time have been a part of the upland prairie and changed to their present condition through erosion and leaching. Areas are, or have been, thickly forested with post oak, small white oak, and in a few places with blackjack. They are commonly spoken of as "post-oak ridges."

The phase is not all under cultivation. Where cleared and farmed, crop yields are considerably lower than on the better types of the county. Clover does well, and bluegrass makes excellent pasturage. The phase is used to a considerable extent in Pike County for strawberries and other small fruits, and some tobacco is grown. Cowpeas and soy beans can be grown with success.

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

Mechanical analyses of Putnam silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
343220.....	Soil.....	0.0	0.0	0.1	2.4	12.4	71.1	13.6
343221.....	Subsoil.....	.0	.4	.4	1.0	1.7	63.1	33.3

BROWN SOILS.

RESIDUAL MATERIAL—LIMESTONE.

HAGERSTOWN SERIES.

The soils of the Hagerstown series are prevailingly brown in color, with light-brown to reddish-brown subsoils. In places the subsoil is red or dull red, but the color is never so pronounced as in the case of the Decatur soils. The Hagerstown soils are typically developed in the limestone valleys of the Appalachian Mountain region and in the central basins of Kentucky and Tennessee, with outlying areas in the adjoining Piedmont Plateau region. The material is residual from limestone. Fragments and outcrops of limestone are of common occurrence. The topography is undulating to gently rolling.

HAGERSTOWN CLAY LOAM.

The Hagerstown clay loam is a deep reddish brown loam to clay loam, rather granular, loose and friable at the surface but becoming heavier with depth. At 6 to 9 inches below the surface it grades into a clay loam or clay, often of mottled brown and gray color. This subsoil extends to depths of 3 feet or more, except where the limestone from which it is derived is encountered at a less depth.

The type is seldom uniform over any considerable areas, as its composition is influenced by many factors, including the character of the original rock, the conditions of weathering and erosion, and the extent to which transported material has modified the surface soil. On the slope exposures of some of the limestone beds the weathered product is black rather than red, but such areas are usually quite narrow. Near the borders of the Shelby loam the type is slightly modified by a thin covering of drift material that has become mixed with the soil. In other places the weathered products of noncalcareous shales have entered into its composition.

The Hagerstown clay loam occurs in numerous areas distributed over all parts of the county except on the broad divides occupied by the Putnam silt loam. Wherever erosion has cut down into the limestone formation patches of this type may occur, although these

are generally not of sufficient size to be indicated on the soil map. The most important bodies of the type are but little more than 1 square mile in area. These areas are usually developed as long, winding, irregular strips, which are distinguished by the exposure of limestone strata along eroded slopes.

This type usually occupies a position between the more level upland and the sharply eroded steep slopes and rocky cliffs of the Rough stony land bordering the streams. Its topography is about a mean between the two. The surface is always rolling, but seldom too rough for cultivation. Drainage is always adequate and in places is excessive. Care is necessary in most places to prevent washing and gullyng.

The Hagerstown clay loam is essentially a residual soil derived from limestone, where the composition of the original rock and the processes of weathering have combined to produce the characteristic red or reddish-brown color. In this county the formations which contribute mainly to the composition of the soil are the Trenton and the Louisiana limestones. The small areas most frequently occur at the horizon of the Trenton and often surround sink holes in that formation. On slopes thin beds weathering under certain conditions give rise to small areas of a very dark, nearly black soil which are included with this type, but the large bodies of black limestone soil are classed with the Leslie series.

The type is well adapted to wheat, clover, and tobacco. Corn produces good average yields. Next to the Knox silt loam this is the best fruit soil of the county. Apples are more extensively grown than any other fruit.

ICE-LAID MATERIAL—MIXED DERIVATION.

SHELBY SERIES.

The Shelby soils are predominantly brown. They range to yellowish brown or yellowish gray and consist mainly of loams and sandy loams. The subsoils are composed of yellow; reddish-yellow or light-brown, tenacious sandy clay, noticeably heavier than the surface soils and to a large extent influenced by remnants of the former loessial covering. The subsoils frequently contain iron pipes and nodular masses and streaks of calcareous material. These soils are derived from the Kansan drift, and occupy steep stream slopes and narrow divides projecting into areas of the Putnam silt loam. They are subject to extensive erosion.

SHELBY LOAM.

The Shelby loam is a light yellowish brown to yellowish-gray light loam to clay loam, loose and friable at the surface, but becoming heavier with increasing depth and grading into a heavy sandy clay

loam or sandy clay at 8 to 15 inches. This heavy subsoil is usually more or less mottled with splotches of brown, reddish brown, gray, and yellow, and contains much more sand than the clay layer of the Putnam. It is also much more pervious to water and more easily penetrated by plant roots. Below 24 inches it is usually slightly lighter and more silty. Owing to its occurrence on the hill slopes, where conditions are favorable for erosion, the surface soil in many places has been partly or entirely removed, leaving the heavy clay layer near to or exposed at the surface so that crop yields are low, especially in case of drought. A cross section where a narrow strip of this soil extends along a small stream into the prairie would show typical gray silty Shelby loam on the outer edges, the reddish-brown subsoil at or near the surface on the edge of the breaks, forming unproductive "scalds," and deep soil partly covered by wash below the scalds. In many places well out on the prairie these narrow strips of reddish-brown soil on the breaks are the only evidence of the underlying glacial till.

The Shelby loam has the widest distribution and, with the exception of the Putnam silt loam, the greatest extent of any soil type in the county. It may be considered the prairie-border soil, the typical Putnam occupying the uplands, and the Shelby the slopes. It is of glacial origin, and if it were not covered in places by loess and eroded on steep slopes and in stream valleys it would probably cover almost the entire county. The material from which it is derived is exposed wherever gullies cut back into the prairie, along the edges of the high terraces in Salt River bottoms, and where streams have cut into the hills in the extreme eastern part of the county. This material can be identified by its gray, yellowish-brown or reddish-brown clay, in which sand grains have been embedded, by water-worn foreign gravel, pebbles, and sometimes boulders, by sharp pieces of chert surrounded by clay, and by occasional beds of partly stratified sand and gravel. Such an arrangement of widely differing materials could result only through the pushing, scouring, grinding, and mixing of an ice sheet.

This material and the soil resulting from it differ widely in different parts of the county. In places in the extreme western and northwestern sections it is quite sandy, some of this sand doubtless resulting from the grinding up of the thin beds of sandstone which occasionally outcrop in this region. Farther east the soil is heavier in texture, a larger part of it being derived from the limestone and shale beds of this hilly region. Near outcrops of limestone it frequently has the principal characteristics of a limestone soil, being similar in color, texture, forest growth, and crop value. In such places it is undoubtedly composed largely of limestone material which

has been moved but a short distance, yet it contains sufficient drift material to identify it as a glacial soil.

In many of the wider valleys narrow strips of this glacial material occur on the gentle slopes below the steep rocky slope which marks the outer edge of the valley proper and the flood plain adjacent to the stream. On these slopes the soil has in many places been modified by wash from the higher areas, limestone soils frequently being washed down in sufficient quantities to form a surface covering. In the eastern part of the county, between the high loess-covered hills on the east and a line which may rather arbitrarily be drawn from Hydesburg through New London to Frankford in Pike County, the Shelby loam has been modified in two ways. In addition to the high percentage of limestone material which this soil originally contained, it has received wash from the steep rock-covered higher slopes, and has been further changed and improved by a thin deposit of silt over the coarser glacial drift. This silt deposit has a thickness of several inches, and usually occurs on the tops of the low ridges, although usually in such small and isolated bodies that it can not be indicated on the soil map. It once doubtless covered much of this part of the county, but has been eroded from the steeper slopes. These areas can be recognized by the uniform light yellowish brown or buff-colored soil, which has a smooth, uniform texture and is unusually productive.

The smooth covering of loess or a mixture of soils of limestone origin with the glacial soils is usually indicated by the forest growth, which consists mainly of black walnut, hard maple, large elm, and papaw.

In addition to these variations, due to silty deposits and to the incorporation of limestone and shale soil, there is another variation where the Shelby loam lies as a narrow belt with the Putnam silt loam on one side and Rough stony land on the other. On the side adjoining the Putnam the soil is gray in color, has a good depth, and approaches the Putnam in productiveness, while on the other side it is lighter in color, the subsoil is heavier clay, and the type is more nearly like the light colored phase of the Putnam. This variation is distinguished by the forest growth, consisting of hickory, laurel oak, elm, hackberry, wild cherry, honey locust, hazel, and wild grapes. This growth occurs mainly on the outer prairie edge. Farther from the prairie these trees gradually give place to black oak, post oak, and white oak. On the extreme edge next to the Rough stony land, post oak and blackjack predominate.

As a whole, the Shelby loam is not as well supplied with nitrogen as the prairie soil, nor does it produce quite as large yields of corn. It also requires greater care in handling to maintain the humus supply and to prevent injury from erosion. It is, however, a warm

soil, and is easily handled. It is well suited to clover. By growing clover and cowpeas, by applying manure, and by practicing crop rotation the type can be made much more productive than it is at present.

The ordinary yield of corn on this type is probably 30 to 35 bushels per acre. That of wheat is about the same as on the prairie. When there is a thin silty surface soil the yields of all crops are greater, some of these areas being as productive as any in the county.

WATER-LAID MATERIAL (RECENT ALLUVIUM)—MIXED DERIVATION.

GENESEE SERIES.

The soils of the Genesee series are brown, varying from dark brown to grayish brown. They are developed along the major streams and their tributaries throughout the northeastern glaciated region, particularly where the Dunkirk, Volusia, Miami, and Ontario series constitute the principal upland soils. They also occur a short distance south of the glaciated region where the main streams flow from areas of these series. The Genesee soils are subject to frequent or annual overflow. The material consists of alluvial sediments.

GENESEE FINE SANDY LOAM.

The soil of the Genesee fine sandy loam varies from a sandy loam to very fine sandy loam. It is light yellowish or grayish brown in color and loose in texture, and as a rule there is little change in color or texture to a depth of 3 feet or more, although in some places the soil below 24 inches contains a higher percentage of fine sand. In places thin layers of sand, gravel, or silty material are encountered.

The type occurs as narrow strips along the larger stream courses. These strips form low natural levees and are made up of the coarser material deposited by flood waters.

This type, although somewhat less productive than the Genesee silt loam, produces fair yields of corn. It is especially suited to water-melons and sweet potatoes.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Genesee fine sandy loam:

Mechanical analyses of Genesee fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
343210.....	Soil.....	0.0	0.3	0.6	21.4	23.9	44.0	9.1
343211.....	Subsoil.....	.0	.0	.4	21.0	26.0	44.3	8.0

GENESEE SILT LOAM.

The typical Genesee silt loam varies from gray to light brown in color and from a very fine sandy loam to light silt loam at the surface, grading slightly heavier with increasing depth. At about 15 inches it passes into a heavy silt loam, which usually has faint mottlings of gray and brown. This either extends to a depth of 3 feet or more or is underlain below 24 inches by a lighter colored silty clay. In some places the deep subsoil grades into a lighter silt loam or fine sandy loam, and in other places into a dark-colored, heavy silt loam or clay loam.

The Genesee silt loam is the most important alluvial soil type of the county. Salt River extends across the county for a distance of about 40 miles and is bordered by a flood plain which varies in width from three-eighths of a mile to almost a mile. From the Brashear Ford eastward the principal and almost exclusive type of the bottom land is the Genesee silt loam. West of this point the bottom land contains more of the gray Waverly soils, but it also comprises important areas of the Genesee. The Genesee silt loam is also the principal soil in the flood plains of Spencer Creek and some of the smaller streams.

A large part of this type occupies first bottoms. It consists of very recent alluvium and is locally known as "made land." At this level the type is overflowed nearly every year. The soil extends over a second bottom, separated from the first bottom by a terrace 6 to 8 feet high and usually well defined, where it is overflowed only at rare intervals.

This type as a whole is the most productive in the county. It is well supplied with nitrogen and humus and produces from 40 to 70 bushels of corn per acre. It gives good yields of wheat, although on account of an oversupply of nitrogen it often has a tendency to make too much straw. It is a good clover soil, and is probably more nearly adapted to alfalfa than any other soil in the county. It is well suited to melons and potatoes. Its most objectionable feature is the danger of overflow. Some areas are in need of thorough drainage.

Genesee silt loam, colluvial phase.—There are grouped under this classification various materials, largely of colluvial origin, the average of which resembles the Genesee silt loam more closely than any other type of the county. This phase occurs along the small drainage channels in the upland and represents wash from adjoining areas of several silty types. The soil brought down wholly from any one upland type resembles the parent material to some extent and is fairly uniform, no great change occurring until wash from another type is brought into the valley. Along the upper courses of

the streams which head back in the open prairie where the Putnam silt loam is the predominating type, the colluvial soils are deep and of a dark-gray color. In some places the upland type grades imperceptibly into the colluvial, but more often there is an intervening strip of the lighter colored Shelby loam. Along some of the larger streams where the light-gray soils of the Waverly series cover the greater part of the valley a narrow strip of the colluvial phase of the Genesee silt loam is found adjoining the stream channel and usually separated from the Waverly soils by a slight terrace.

After the streams pass from the prairie region into sharply cut valleys they are in many places bordered by soils which are so mixed that they can hardly be separated into types. Sand from the glacial material enters largely in their composition, and fans and deltas are included which contain small beds of gravel and rock fragments. The broad valleys are largely covered by uniform areas of soils of the Genesee and Waverly series, but immediately before the mouths of small tributary streams there are deltas of silty materials brought down from the upland. In nearly all such areas the colluvial wash from the immediate hills has encroached upon the valley soils, the one passing imperceptibly into the other. The dark-gray soils, largely colluvial but often modified by alluvial deposits occupying narrow valleys on the borders of the large valleys and usually of a silty texture, have been broadly grouped under the colluvial phase of the Genesee silt loam.

This phase is for the most part uncultivated on account of its poor drainage. It is made up of the wash from the best soil of the surrounding uplands, and with proper drainage and cultivation is capable of producing much higher yields than the adjoining eroded lands, yet because of the cost of drainage and the difficulty of bringing it under cultivation it has been allowed to grow up in weeds and brush. In many places the area of this soil could be profitably increased by throwing obstructions across the small stream, so that the wash can be caught and converted into soil.

WATER-LAID MATERIAL (OLD ALLUVIUM)—MIXED DERIVATION.

JACKSON SERIES.

The Jackson soils are brown, ranging to light brown; the subsoils are brown or mottled. These soils occupy second bottoms along the small streams in the glaciated areas of the Coastal Plain States. They are intermediate in position between the Wabash soils of the River Flood Plains and the Judson soils of the Glacial and Loessial Province. In color and relation to streams they are about similar to the Lintonia soils. The material of the Jackson series, however, is derived mainly from drift, modified by wash from loessial and re-

sidual soils. The soils are partly alluvial and partly colluvial in mode of formation. As a rule, they are not subject to overflow.

JACKSON SILT LOAM.

The soil of the Jackson silt loam is a gray or grayish-brown, smooth silt loam having a depth of 8 to 10 inches. The upper part of the subsoil is an ashy-gray, loose, smooth, almost pure silt. At a depth of 16 to 20 inches this material passes abruptly into a dark-gray, heavy silty clay loam, which grades into a compact silty clay. There are usually slight mottlings of light and dark gray in the lower subsoil, and more rarely there is a solid yellow color or mottlings of yellow and gray. At a depth of about 26 inches iron concretions are encountered, increasing in quantity with depth. In this type the arrangement of the layers of material as well as the character of the material itself is not unlike a large part of the Genesee silt loam, and is no doubt an elevated body of what was formerly that type.

The Jackson silt loam occurs in several areas in the central and eastern sections of the county. These are usually of irregular shape, as they occupy remnants of ancient terraces, which have been left in narrow fringes along the hillsides. The largest areas are found where a number of streams entering a valley have built up a flood plain of considerable width. The subsequent elevation of the land left this as a terrace in a somewhat sheltered position from action of the main stream.

The surface of this type is for the most part nearly level or very gently rolling. In some of the areas, however, the surface has been modified by erosion until it is rolling and the terrace shape is now indistinct.

The Jackson silt loam is not as productive as the better upland soils, particularly the Putnam silt loam. Corn, wheat, and other general farm crops common to this region are grown.

FOX SERIES.

The Fox soils are predominantly brown, ranging to gray. They have a generally level topography, varied only by the occurrence of potholes or of valleys eroded subsequent to the deposition of the material. The material was deposited as outwash plains or as terraces along streams within or flowing out of the glacial region. It is largely or wholly glacial-derived material, but contains a high percentage—at least 25 per cent—of limestone.

FOX FINE SANDY LOAM.

The surface soil of the Fox fine sandy loam to a depth of about 15 inches is a light-brown or brownish-gray sandy loam to fine sandy loam. The soil is lighter in texture near the surface, but becomes

heavier with depth, passing gradually into the subsoil, which consists of a brownish-yellow loam. The subsoil varies from sticky and rather plastic to loose and friable. There is a large percentage of silt in the soil, and in most places a larger amount in the subsoil. Water-worn gravel is scattered over the surface and distributed throughout the soil and subsoil. Below 24 inches the subsoil gradually becomes heavier, passing into a reddish-brown sandy clay, and the gravel content increases. This material closely resembles the deeper subsoil of the Shelby loam. There is a steady increase in the percentage of coarser material until at a depth of 5 to 6 feet beds of sand and gravel in such quantity as to be of commercial value are encountered. These coarse materials are cross-bedded and stratified in a very irregular manner. Though generally loose and porous, this substratum is too far beneath the surface to affect injuriously the water-holding capacity of the soil, but it insures good underdrainage.

This type, though developed in several small areas on remnants of eroded terraces, occurs in only one area of sufficient size to be shown separately on the soil map. This area occupies a terrace along the Mississippi, surrounding the town of Saverton. It is flanked on one side by steep hillsides and on the other there is an abrupt drop to the river bed.

The topography is nearly level, except on a small part of the type, where erosion has been active. The natural surface drainage is good, and owing to its elevation above the river the type is not subject to overflow.

The Fox fine sandy loam is a productive soil, well suited to all the general farm crops common to the region. It is also adapted to the production of vegetables, and since the transportation facilities are excellent there is a good opportunity for the trucking industry. The city of Hannibal is only 6 miles distant and there is a railroad station at Saverton.

WIND-LAID MATERIAL—MIXED DERIVATION.

KNOX SERIES.

The Knox soils are light brown. The greater part of the soil consists of material formerly called Miami silt loam, where this type was derived directly from the loess. The loessial covering of the Knox series is always thick enough to form the subsoil as well as the surface soil, the deeper lying glacial till being far enough from the surface to have no marked influence on the general character of the soil. These soils occur mainly in the Central Prairie States. They are derived from loessial or other wind-blown deposits. The topography is gently undulating to rolling, and surface drainage is generally good.

KNOX SILT LOAM.

The soil of the Knox silt loam is a light yellowish brown to buff, smooth, very light silt loam having a velvety feel. Below a depth of 16 to 18 inches the material becomes lighter in texture, but the color remains the same to a depth of more than 36 inches. Where cut into by roads or streams, the formation from which the soil is derived stands up in perpendicular walls, and where undermined it flakes off in long, columnar masses. In the larger areas of the type in Pike County, this silty material has a thickness of 20 to 60 feet and the soil constitutes one of the most productive, best-drained and at the same time the best moisture-retaining types of the State. The deposit is invariably thickest near the river, thinning out away from it. The texture also varies, gradually becoming slightly lighter as the distance from the stream increases.

The small and relatively unimportant areas of the type mapped in Ralls County occupy the tops of hills and ridges in the northeastern part of the county. There are in addition to these areas numerous small patches of the type too small to indicate on the map, included with the Knox silt loam, heavy subsoil phase.

The topography is gently rolling. On the steeper slopes areas where the soil is thinner than usual and the underlying material is frequently exposed have been included with Rough stony land.

As the Knox silt loam occupies only small areas, it is of little agricultural importance. The smoother land is very productive and suited to a wide range of crops. Wheat yields 15 to 30 bushels per acre and corn 40 to 60 bushels. Clover, alfalfa, tobacco, and truck crops do well, and apples and small fruits are grown to some extent.

The type was originally forested with white oak, elm, walnut, maple, and papaw.

Knox silt loam, heavy subsoil phase.—The surface soil of the Knox silt loam, heavy subsoil phase, is a yellowish or brownish-gray silt loam or rather heavy silt loam, not greatly different in color and texture from the soil of the main type. At a depth of 6 to 8 inches it passes into a yellow heavy silt loam or more rarely a silty clay loam, and at 16 to 20 inches the lower subsoil is encountered, consisting of a yellowish-brown, compact silty clay loam or silty clay. In some places this material is brown mottled with gray, or the solid brown color may be separated into irregular sections with the dividing lines marked by gray. Below 30 inches the structure is more friable and iron concretions are often abundant.

In general the surface appearance of this phase does not vary greatly from typical Knox silt loam, but the separation is made upon the basis of the heavy, compact subsoil and the difference in productivity.

The soil is not uniform over any large areas. The most common variation is the presence of numerous small areas of the typical Knox silt loam, which can not be satisfactorily indicated on the map.

The surface of the phase varies from sharply to gently rolling, the topography of any given area depending upon its position in relation to streams and its exposure to erosion. The watercourses are rapidly extending back into the soft, silty material from which this phase is derived, so that the greater part of the total area now consists of narrow strips of very irregular shape. The larger bodies occur on the divides where erosion has been less active.

The heavy subsoil phase of the Knox silt loam is the predominant soil over a strip of country about 4 miles wide, extending across the northeastern part of the county in a northwest and southeast direction. It includes that part of the county which is drained directly into the Mississippi River. About two-thirds of this belt is covered by the phase, which occurs in numerous areas, few of which are more than 1 square mile in extent. They occupy the higher hills and ridges. In the intervening valleys the steeper slopes where the silty material has been removed, exposing the basal limestone, are included with the Rough stony land, and alluvial soils occupy the flood plain bordering the stream.

This soil is of doubtful origin. The main type is derived from loess, but in this county the heavy subsoil phase doubtless includes other materials, and it is not clear to what extent wind-blown material has entered into its composition. It is highly probable that in many places the thin covering of loess has produced the silty soil and a soft shale or glacial till derived mainly from shale has weathered into the silty clay subsoil, but as the two materials are so similar this is not certain, and from a soil standpoint it is not important.

This phase is a less productive soil than the main type, and its areas are not thickly settled. The same type of farming is practiced as on other soils of the county. The usual farm crops of the region are grown but the average yields are low.

Much of this land has been cleared within the past few years, and is being used for truck gardening and the production of small fruits to supply the markets of Hannibal and Ilasco. Good results are being obtained and the industry is being extended. This is an excellent fruit soil, and a considerable acreage of it is being used for apple orchards. Near Saverton, where the soil approaches closely the typical Knox silt loam, it supports the largest and most profitable commercial orchard in the county.

The characteristic forest growth of the typical loess is black walnut, hard maple, large white oak, elm, and papaw. Few of these trees are found on this phase, the principal growth being scrubby

white oak, post oak, and some black oak and blackjack, trees which are usually confined to a rather inferior soil.

The results of mechanical analyses of samples of the soil and subsoil of the Knox silt loam, heavy subsoil phase, are given in the following table:

Mechanical analyses of Knox silt loam, heavy subsoil phase.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
343201.....	Soil.....	0.2	0.3	0.4	1.3	5.4	82.0	10.2
343202.....	Subsoil.....	.0	.1	.3	.3	5.9	65.6	27.9

GRAY SOILS.

WATER-LAID MATERIAL (RECENT ALLUVIUM)—MIXED DERIVATION.

WAVERLY SERIES.

The surface soils are light gray. The subsoils are gray or mottled yellowish and grayish. This series is typically developed in the drained parts of the first bottoms of streams flowing through and issuing from the loessial region of the Central Prairie States. The soils are subject to overflow.

WAVERLY FINE SANDY LOAM.

The Waverly fine sandy loam is a gray to almost white fine to very fine sandy loam, underlain at about 15 inches by a light-gray silt loam carrying large quantities of iron concretions, or by a fine sandy loam, the material differing but little in color or texture to a depth of 3 feet or more. This type is more productive than the Waverly silt loam, and gives good yields of corn, wheat, and oats. It is especially suited to melons, sweet potatoes, and garden truck.

Small areas of this type occur south of Mount Pleasant School, and both northeast and southeast of Yeager School, in the western part of the county.

WAVERLY SILT LOAM.

The Waverly silt loam is a light ashy gray, almost white silt loam which is light in texture at the surface, becoming heavier with increasing depth. At about 12 inches it grades into a heavy silt loam, somewhat mottled with gray and yellowish brown. At about 22 inches this usually passes into a stiff, tenacious, peatlike clay which is also mottled with gray, yellow, and brown. On the surface and scattered through the soil and subsoil are numerous small iron concretions. These are usually most abundant immediately above the

heavy subsoil, and in places they are cemented together to some extent, forming the nearest approach to a true hardpan found in the county. Such places usually occur in areas of restricted drainage.

Next to the Genesee silt loam the most important bottom-land soil in Ralls County is the Waverly silt loam, commonly spoken of as "white land." It is alluvial in origin, having been derived from wash carried down from the loessial and glacial soils of the uplands. The type occurs principally on low benches or second bottoms separated from the adjoining but low-lying, darker colored Genesee soils by a distinct rise varying in height from 4 or 5 to as much as 10 feet. In some places there are two or more benches, and on the stream side the Waverly silt loam is sharply defined while on the opposite side it passes gradually into areas of a darker soil resembling the Genesee. Another sharp rise marks the border of another strip of Waverly, and this grades into darker soils in the same way, so that while there is usually a distinct boundary on one side of the areas of this type on the other side the boundary is not clearly defined. Some areas are subject to overflow during the higher stages of water. A large part of the type is poorly drained. The forest growth consists mainly of water oak and post oak.

This type, although not so productive as the darker colored soils of the county, gives fair yields of corn, wheat, and oats. It is well adapted to timothy and redbtop, and in places clover does fairly well. A part of the type can be improved by drainage. For improving this soil the application of manure, the growing of legume crops, and using the land for pasture are required.

Waverly silt loam, heavy phase.—There are several areas of the Waverly silt loam in which the soil differs from the typical in being heavier, slightly darker in color, more granular, and usually when well drained, more productive. These areas are mapped as the heavy phase of the Waverly silt loam. Small, poorly drained areas of this phase, too small to be shown separately on the soil map, occur in many places within bodies of the typical soil and have not been separated from it. Near Cross Roads Church, however, there is a rather large body of alluvial land in which this heavy phase of the Waverly silt loam is predominant.

MISCELLANEOUS MATERIALS.

ROUGH STONY LAND.

The most widely distributed soil type in the county and excepting the prairie and prairie-border soils, the most extensive, is the Rough stony land. Strips of this type follow the meandering course of Salt River Valley entirely across the county, and extend well back into the uplands along each of its tributaries. It follows the valley of

Bear Creek in the northern part of the county and Spencer Creek and Lick Creek in the southern part.

The Rough stony land of Ralls County comprises rocky areas, resulting from the breaking down of alternating beds of hard limestone and soft shale. Where either shale or limestone beds alone are exposed a soil mantle is soon formed and the underlying rocks protected, but where they alternate the shale weathers and erodes rapidly, working back until it finally undermines the limestone along the edge of the valley and around the heads of the small streams. The limestone then falls in large masses, and steep, rock-covered slopes are developed. Where the limestone contains large quantities of insoluble chert this is left on the slope after the limestone has been entirely changed to soil.

The beds which have had the greatest influence in the formation of Rough stony land areas are the Burlington and Chouteau limestones, which lie immediately below the edge of the uplands in the central and western parts of the county and cap the high hills in the eastern part. These beds contain large quantities of hard, insoluble chert and are underlain by the soft Hannibal shale, into which the small streams work rapidly, leaving steep, chert-covered slopes. On some of these slopes adjoining the glaciated areas glacial clay and foreign boulders and pebbles are frequently encountered. In some places a thin-bedded limestone above the Hudson River shale is exposed on the slopes, leaving large areas of shale limestone, which often support clumps of cedar. The outcrops of Trenton limestone are confined principally to perpendicular bluffs and nearby steep slopes, on which the soil is black and productive. In the eastern part of the county some areas, which are covered with loess but have slopes so steep that the soil can not be cultivated, are included with this classification.

In the areas mapped as Rough stony land there are in many places small bodies of soil which can be cultivated. Some of these, especially near the chert-covered slopes, have light ashy gray surface soils which resemble that of the Putnam silt loam, light colored phase. Others are more like the Shelby loam, the Hagerstown clay loam, or the Leslie clay loam, but these are patches in most cases too small to be shown separately on the soil map.

Where cleared the Rough stony land is used almost exclusively for pasture, and much of it supports a good stand of blue grass. A larger area could be profitably cleared and used for this purpose. The forest growth depends upon the character of rocks forming the slope. In the cherty areas it consists of scrubby white oak, post oak, black oak, and blackjack, on the bare limestone slopes of cedar and on the Trenton formation, walnut and hard maple. A part of the Rough stony land is best adapted to forestry.

SUMMARY.

Ralls County is located in northeastern Missouri. It has an area of 481 square miles, or 307,840 acres. The topography varies from level or gently rolling in the southwestern and northwestern prairie sections to hilly and eroded near the Salt River and in the eastern part.

The county is drained almost entirely by the Salt River and its tributaries. A small area in the extreme northern part of the county is drained by the North and South Rivers and by Bear Creek, and another small area in the eastern part by tributaries of the Mississippi River.

Ralls County has been permanently settled for nearly a hundred years. It has a population, according to the 1910 census, of 12,913. The county has no large towns, New London, the county seat, in the eastern part, being the largest, with a population of about 1,000. Several large towns just outside the county, however, constitute good markets for local products.

The railroad facilities are good, and although the county roads are generally in poor condition, they are being improved, an abundant supply of excellent road-building material being available within the county.

The average annual temperature is about 53° F. Extreme temperatures are rare, although abrupt changes often cause crop injury. Extremely heavy rainfalls and droughts are uncommon. The annual rainfall averages about 33 inches. The precipitation is well distributed throughout the year and is adequate, where the soil water is properly conserved, for good crops. There is an average growing season of about 6 months.

The agriculture of Ralls County consists mainly of stock raising combined with grain farming, supplemented by dairying, poultry raising, gardening, and the production of apples and small fruits. The principal farm crops are corn, wheat, clover, timothy, and oats. Cowpeas, millet, alfalfa, redtop, sorghum, and kafir are also important. Corn produces an average of 32 bushels, and wheat an average of 14 bushels per acre. The use of commercial fertilizers is receiving increasing attention. The value of the rotation of crops is being more deeply appreciated. But little effort is made to prevent or check soil erosion. Many areas in the county are in need of drainage.

There is a great need in the county for the improvement of the live stock. Through indifference on the part of the farmers considerable low-grade and scrub stock has been introduced. In general, stock raising is most important in the western part of the county and the production of grain receives greater attention in the eastern sections. The interest taken in improved methods of farming and

modern implements is increasing, and in this connection the farmers of the prairie sections are the most progressive.

Land values range from \$75 to over \$100 an acre for the better prairie and hill lands to as low as \$25, or possibly less, for the eroded and rocky ridges and hill land.

The soils of the county fall into four general groups—the residual, glacial, loessial, and alluvial soils.

The partly loessial prairie soil, classed as the Putnam silt loam, is fairly uniform through the county.

The glacial prairie border soil, mapped as the Shelby loam, varies from glacial material which contains much sand and considerable amounts of foreign gravel and pebbles, in the regions bordering on the prairie, to soils which contain a higher percentage of limestone material and loess, nearer the rock outcrops. The latter soils are the more productive.

The silty soils, probably of loessial origin, occur in the eastern part of the county. The greater part of the soil is heavier in texture and somewhat less productive than the typical Knox silt loam, with which it has been correlated.

Of the residual soils the Rough stony land is by far the most extensive. The greater part of this is nonagricultural, and its wide distribution greatly reduces the average value of the land of the county. Very small areas of two other residual soils are mapped—the Hagerstown clay loam, largely from the Trenton limestone, and the Leslie clay loam, from Coal Measure shales.

Two classes of alluvial soils are recognized—the darker colored, more recently formed, and more productive Genesee soils, and the light-gray, bottom-land Waverly soils.



[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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