

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE UNIVERSITY OF MISSOURI AGRICULTURAL
EXPERIMENT STATION, F. B. MUMFORD, DIRECTOR;
M. F. MILLER, IN CHARGE SOIL SURVEY.

SOIL SURVEY OF KNOX COUNTY,
MISSOURI.

BY

H. H. KRUSEKOPF, OF THE UNIVERSITY OF MISSOURI, IN CHARGE,
AND H. I. COHN, OF THE U. S. DEPARTMENT OF AGRICULTURE.

THOMAS D. RICE, INSPECTOR, NORTHERN DIVISION.

[Advance Sheets—Field Operations of the Bureau of Soils, 1917.]



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1921.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., April 2, 1920.

SIR: In the extension of the soil survey in the State of Missouri during the field season of 1917 a survey was undertaken in Knox County. This work was done in cooperation with the University of Missouri Agricultural Experiment Station.

I have the honor to transmit herewith the manuscript report and map covering this work and to request their publication as advance sheets of Field Operations of the Bureau of Soils for 1917, as authorized by law.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

HON. E. T. MEREDITH,
Secretary of Agriculture.

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MAP.

Soil map, Knox County sheet, Missouri.

SOIL SURVEY OF KNOX COUNTY, MISSOURI.

By H. H. KRUSEKOPF, of the University of Missouri, In Charge, and H. I. COHN, of the U. S. Department of Agriculture—Area Inspected by THOMAS D. RICE.

DESCRIPTION OF THE AREA.

Knox County, Mo., is located in the northeastern part of the State, lying 35 miles south of Iowa, and in the second tier of counties west of the Mississippi River. The county has an area of 514 square miles, or 328,960 acres, of which approximately 95 per cent is tillable.

Knox County is included entirely within the physiographic division of Missouri, known as the Northeast Level Prairie. In general, this region is a smooth to gently rolling plain, with a gradual slope to the south-east. At present the area with a rolling surface is more extensive than that of smooth topography, but in every part of the county there is evidence of the former existence of a uniform plain.

Locally the topography varies from level to rolling, with small areas moderately hilly. The western and southern parts of the county are prevailing level to gently rolling and the northeastern part includes the greatest extent of rolling and hilly land. In general, the level land forms the broad, flat prairies, varying from 1 to 6 miles in width, occupying the divides between the larger streams. The most extensive of these extends from Hurdland to Novelty and south to the county line. A similar belt extends from near the northwest corner of the county in a southeasterly direction, passing out of the county east of Knox City. Along the streams, and thus fringing the prairie areas, are belts of rolling land, characterized by short slopes of moderate gradients. Only in the northeastern part of the county, north of Knox City, is all of the surface dissected, and here many of the slopes are so steep as to make cultivation difficult. In the southeastern part of the county along South Fabius River limestone outcrops form cliffs that rise from 10 to 60 feet above the valley floor. These small outcrops constitute the only waste land in the county. As a whole, the county lacks striking physiographic features. It comprises an unusually smooth part of the State.

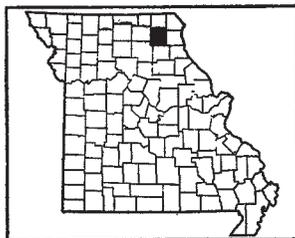


FIG. 1.—Sketch map showing location of the Knox County area, Missouri.

The altitude of Knox County varies from about 900 feet above sea level on the prairie in the northwestern part of the county to about 650 feet in the valley of the South Fabius near Newark. The general elevation is between 750 and 800 feet. The altitude of some of the places in the county is as follows: Hurdland, 880; Edina, 840; Knox City, 760; Baring, 808; Novelty, 820; Millport, 700; Colony, 746.

Four main streams—North Fabius, Middle Fabius, South Fabius, and Salt River—flow in a southeasterly course across the county and, with their tributaries, constitute the drainage system. The tributaries, as a rule, maintain courses parallel to the main streams, and the later branches are therefore relatively short. All the streams have comparatively wide flood plains. They occupy mud-lined channels and the water is usually muddy or, at least, remains turbid throughout the year. Springs are of rare occurrence in the county, but there is no difficulty in obtaining an abundance of water in dug wells, usually between depths of 35 and 70 feet.

The streams are characterized by their numerous meanders within their valleys. These meanders greatly retard the flow of water and also cut up the bottom land so as to make the cultivation of much of it impracticable. Salt River and South Fabius River have been ditched and dredged, with the result that the gradient of the streams has been increased and much valuable land reclaimed. By straightening many other of the stream channels the danger of overflow could be greatly reduced and the value of the bottom lands enhanced.

Knox County was first settled in 1833. Many of the early immigrants came from Ireland, and their descendants form a large percentage of the population at the present time. The total population of the county in 1910 was 12,403, all of which is classed as rural, or an average of 24.1 persons per square mile. Edina, the largest town, has a population of 1,562.¹

CLIMATE.

Knox County has a healthful, temperate climate, marked neither by prolonged hot or sultry weather in the summer nor extreme cold in the winter. The annual average temperature is 53.4° F., as compared to 54° F. for the State. The growing season is a little more than six months, the average date of the last killing frost in spring being April 19 and of the earliest in the fall October 9. Killing frosts may occur, however, as late as May and as early as September, though such occurrences are rare.

¹Since this report was written the preliminary announcement of the population of Knox County and its civil divisions in 1920 has been issued by the Bureau of the Census, as follows: Knox County, 10,783; rural, 10,783; Baring, 248; Edina, 1,438; Hurdland, 325; Knox City, 400; Newark, 220; Novelty, 227.

The average annual rainfall is 38.75 inches. Precipitation is well distributed through the year, the heaviest occurring during the spring and summer months. The average annual snowfall is about 15 inches.

The following table gives the normal monthly, seasonal, and annual temperature and precipitation as recorded by the Weather Bureau station at Steffenville, in Lewis County. It is believed the figures fairly represent conditions in Knox County.

Normal monthly, seasonal, and annual temperature and precipitation at Steffenville, Lewis County.

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.....	30.4	72	-18	1.71	1.63	1.70
January.....	28.7	74	-22	2.32	1.17	2.54
February.....	26.7	74	-11	2.04	2.97	2.62
Winter.....	28.6	74	-22	6.07	5.77	6.86
March.....	41.7	89	-6	2.89	3.72	1.47
April.....	52.7	91	22	3.63	1.30	2.47
May.....	64.4	100	30	5.28	4.12	6.04
Spring.....	52.9	100	-6	11.80	9.14	9.98
June.....	72.9	107	40	3.89	2.45	9.63
July.....	77.4	113	49	5.09	.15	11.84
August.....	76.8	109	41	3.47	1.12	6.26
Summer.....	75.7	113	40	12.45	3.72	27.73
September.....	68.6	109	30	4.45	2.09	7.79
October.....	57.2	94	19	2.10	1.70	.75
November.....	43.8	85	2	1.88	2.65	3.60
Fall.....	56.5	109	2	8.43	6.44	12.14
Year.....	53.4	113	-22	38.75	25.07	56.71

AGRICULTURE.

The agriculture of Knox County is highly developed and is typical of the Corn Belt. The favorable soil, climate, and topography permit of a highly improved system of farming and the utilization of all the land. The farm units are relatively large and the farm practices are of the extensive type.

The agriculture of the county from its beginning to the present time has been based on general farming combined with the production of live stock. The extensive prairies and the grassy woodlands

avored the development of the live-stock industry, and stock raising was begun by the early settlers. The prairie lands were likewise easily and quickly brought under cultivation, so that the growing of corn, wheat, and oats developed with the stock-raising industry.

Before the building of the railroads in 1878, wheat and live stock, which formed the only sale products, were carried to the Mississippi River, 25 miles to the east, for shipment. The period from 1870 to 1890 was marked by most rapid development in the agriculture of the county. At present (1917) practically all of the tillable land is under cultivation. The small areas of steeply rolling land are used for woodlots and permanent pastures. All of the land is used in some way for agricultural purposes.

Corn, grass, oats, and wheat are the chief crops. They are important in the order named, both in acreage and value. Wheat, however, is relatively an unimportant crop. The average net return from wheat is greater than from oats, but neither of these crops would be grown so generally were it not for the necessity of frequently seeding the land to grass or clover. This is recognized by the farmers as absolutely indispensable in good farm management. In most instances the problem of maintaining fertility is considered chiefly in its relation to the production of corn. The demand for this grain is stimulating interest in every means that promises greater average yields. On the whole, the farm practices are good; crop rotation is practiced, manure and fertilizer are used, the value of leguminous crops is appreciated, and thorough plowing and preparation of the seed bed is the rule.

Corn has always been the main crop of the county. The average planting is about 70,000 acres and the average yield per acre is 28.3 bushels.¹ Some commercial fertilizer is used in the production of corn, but barnyard manure is chiefly employed. Fertilizers may be used with profit to increase the yields, but these should be supplemented by other means of maintaining the productiveness of the soil, such as crop rotation and green manuring. The planting of cowpeas or soy beans in the corn for ensilage is becoming a general practice. The advantage of growing a legume with corn can readily be appreciated, as it adds organic matter and nitrogen to the soil, although the legume may lessen the yield of corn somewhat. It is probably the best plan to grow legumes only when the corn is used for ensilage or is to be harvested by live stock.

Oats are extensively grown, but are not always a profitable crop. The area planted averages about 23,000 acres and the yield about 23 bushels per acre. The yield in favorable seasons is from 50 to 60

¹ Missouri Crop Review, 1916, Missouri State Board of Agriculture.

bushels per acre, but in some years the crop is almost a failure. Less attention is given to the fertilizer needs and to seed-bed preparation than to any of the other grain crops.

Wheat in recent years has occupied about 1,700 acres and the average yield has been 13.4 bushels per acre. Practically all of it is grown on the prairie soils. Fertilizer is rather commonly used at the rate of 100 to 200 pounds per acre, for without such treatment the yields are rarely profitable. The use of phosphate fertilizer, such as acid phosphate or bonemeal, gives the best results although mixed fertilizers high in phosphoric acid give satisfactory increase.

The average area devoted to hay crops is about 46,000 acres, an area exceeded by only a few counties in the State. The hay consists of timothy almost exclusively. A large proportion of the crop is harvested for seed. Most of the crop is grown on the level prairie land. Only a few hundred acres are devoted to clover, which means that the majority of farmers do not grow the crop, and it is not generally included in the crop rotation. Failure to recognize the need of growing clover is probably the most objectionable feature of the farming system of this region. With the exception of some parts of level gray prairie, all the soils grow clover. The importance of this crop as a cattle feed and as a means of building up the soil should cause it to become one of the most important crops of the county.

The pastures consist of bluegrass almost exclusively, and the luxuriance and permanence of this valuable grass have been the main factors in developing the important live-stock industry found here. Little difficulty is found in getting a stand, and when once the grass is started the sod is practically permanent. On the prairie soils, however, there are no permanent pastures. Land that is run down is usually seeded with grass and clover, used for pasture a few years, and then planted again in corn.

The hay and pasture crops are the main reliance for building up fertility. Red clover, through its power to take free nitrogen from the air and deposit it in the soil, replaces much of this important plant food taken out by other crops. The mass of grass roots which develop in the soil, and the clover, grasses, and weeds not eaten by animals, furnish the matter which, when rotted down, supplies humus. In addition, some benefit is derived from the manure of animals pasturing on these fields.

Cowpeas and soy beans are grown to a very small extent as a hay crop. As forage crops and as green-manure crops these legumes are valuable, and they should be used more generally in the farming system of the region.

Alfalfa is of almost negligible importance. It is not well suited to the prairie lands with heavy subsoil, and does best on the better bottom soils and the black glacial soils.

In the last few years sorghum has been grown extensively as a hay crop, and to a limited extent is displacing timothy. From 3 to 5 tons of fodder are produced per acre.

Rye is grown on some of the thinner glacial soils. It is occasionally used as a nurse crop when thin land is to be seeded to grass and clover, since it makes less demand on the supply of soil moisture than either wheat or oats. No crop is more effective as a cover or green-manure crop.

Little attention is paid to the production of apples or other orchard fruits, and not enough fruit is grown to supply the local demand. The orchards are generally small and in most instances not well cared for. The level prairie soils are not so well suited to orchards as the better grade of rolling land, for the trees on the latter make a more vigorous growth and live longer. The opportunity for fruit culture here is quite as good as in any part of northeast Missouri. The typical Grundy and the better Shelby soils afford the best sites for orchards. It is not probable that fruit growing will become an industry of great importance, since other lines of agriculture give as good returns and are less hazardous.

The raising of live stock is the most prominent feature of the farming system. It is the main source of income on practically every farm. Many of the larger farms are devoted almost exclusively to the production of purebred animals. Horses, mules, cattle, sheep, and hogs are raised in large numbers. Feeder cattle are frequently shipped into the county to be fattened for market.

In general, those farms that have the largest proportionate number of live stock to the number of acres are the most successful and produce the largest average yield. The number of live stock is one for each 16 acres of farm land, or, if all the live stock on the farm were numbered in terms of beef animals, it would mean that one beef animal is kept for every 16 acres of land. For the State the ratio is about 1 to 19; in most of the better counties it is about 1 to 10. It is impossible to tell definitely just how many cattle, dairy cows, sheep, or hogs a farm of a given size should have, but it would seem that for the region as a whole the number of animals could be increased with profit. In general, crop yields increase with the increasing number of live stock.

The total number of live stock in the county in 1917 was as follows: Horses, 7,743; mules, 1,910; cattle, 19,280; sheep, 6,510; hogs, 8,738.

Dairying is of no commercial importance, although some of the farms near the railroad towns produce cream for export. On account of the excellent pastures this industry can easily be developed. Dairying can be made to yield a profit in itself, and is the most economical means of producing stable manure, which is so essential in the present system of farming for the production of large yields.

The practice of rotating crops is one of the means of keeping the soil in proper condition and of increasing and maintaining yields. Each crop has its own peculiar root system and its own special way of getting food from the soil. It is recognized that fixed rotations can be followed with difficulty, but a study of farming in this region shows clearly that a rational crop rotation, followed with as much regularity as conditions will allow, is the basic factor in maintaining and increasing crop yields.

A systematic crop rotation is practiced by few farmers of this region. Probably the most common rotation is corn two years, followed by oats, and this by two or three years of grass. This is very satisfactory, provided clover is an important part of the grass mixture. Rye may be seeded in the corn the first season for fall and spring pasture, and cowpeas or soy beans the second year, to be pastured or turned under.² Such a rotation, with the proper handling of manure and crop residue, should rapidly build up the soil or at least maintain the organic matter content. To increase the chance of a good stand of clover and to stimulate its growth, liming is usually to be recommended. The aim in each rotation should be to return sufficient organic matter, preferably in the form of legumes, to the soil to maintain the supply of this material.

For general farm purposes, stable manure is the best fertilizer known, since it contains all the essential plant foods and is instrumental in making more available the plant foods already in the soil. Under the present system of cattle feeding only a very small amount of manure is produced. Stall feeding is not generally practiced, and the lack of straw bedding does not permit of manure being obtained in quantity sufficient to meet the soil needs. This condition can not be remedied without a change in the present agricultural practices which would necessitate the growing of more small grain and a more intensive stock-feeding industry.

The amount of organic matter and nitrogen obtainable from crop residues is at best small, and with the limited manure supply it is necessary to grow cover crops in order to maintain the supply of humus in the soil. The growing of rye on stalk ground during winter, and cowpeas or soy beans in corn to be pastured or plowed under are good practices. The greatest dependence for supplying organic matter, however, should be placed on red clover and crop residues. On the eroded glacial soils sweet clover is valuable because of its strong growth. These legumes not only furnish organic matter when turned under, but they are capable of adding nitrogen also. Through bacteria living in nodules on their roots they are capable of

² Missouri Agricultural Experiment Station Bulletin No. 127, Soil Experiments on the Dark Prairies of Central and Northeast Missouri.

appropriating free nitrogen from the air. A good crop of clover contains 80 to 100 pounds of nitrogen per acre. Ten tons of good barnyard manure contains about 100 pounds of nitrogen. Most of the nitrogen in clover is from the air, and is therefore a distinct gain.

Green manuring has a place under the existing farming conditions, in addition to the use of farm manure and crop residue. No other method of maintaining the nitrogen content of the soil is so cheap and so efficient. To keep up the humus of the soil, more than 10 tons of manure would be required once in a four-year rotation. The amount and frequency of application of green manures or farm manure can not be definitely stated, but should be greatest on the thinner soils and those most heavily cropped with grains. In general, it is better to make frequent applications than one very large addition.

The use of commercial fertilizer to supplement stable manure is becoming more general. Analysis shows that practically all the soils are rather low in phosphorus, but are well supplied with potassium. This is further indicated by the uniformly profitable returns from the use of phosphatic fertilizers. This is particularly true for wheat, which is greatly improved both in quality and yield. Applications of 150 to 300 pounds per acre of acid phosphate or bone meal are recommended. Mixed fertilizers containing 10 to 12 per cent of available phosphorus and 2 per cent of nitrogen may also be used with good results. Small amounts of potash in the fertilizer often prove profitable. Under proper methods of farming, however, which includes the liberal use of organic matter, potassium need not be supplied to the soils. Nitrogen is much more cheaply and better supplied in manure and green manure crops than in a fertilizer.

Most of the prairie soils are more or less acid. The difficulty of growing clover is largely due to this condition. Bluegrass, too, thrives best and makes a denser sod on soils that are least in need of lime. The use of lime should prove profitable on all the soils most in need of it. On soils deficient in this element it is as necessary to make good this deficiency as it may be to make good the deficiency of nitrogen or phosphorus. Lime does not take the place of other fertilizing elements, but only accomplishes its full effect when used in connection with liberal manuring and fertilizing. Ground limestone applied at the rate of 1 to 3 tons per acre once every four to six years should give good results on land in cultivation, especially where clover is grown in the rotation. The limestone in the southeastern part of the county consists of rather pure carbonate rock, and where not too deeply covered with soil material could be used for the production of agricultural lime.³

³ Missouri Agricultural Experiment Station Bulletin No. 171, Agricultural Lime.

Poor drainage is one of the most important causes of low yields and occasional crop failures on the level prairie lands in Knox County. Partial crop failures due to this cause occur on an average two years in five. On account of the level surface and the compact subsoil of much of the prairie land, water may stand on the surface or drain away so gradually that the cultivation of the land may be delayed many days, and growing crops will not do well. Tiling the land has not as yet been undertaken generally. In those few cases where tiling has been tried the results have in general proved satisfactory. The general conclusions drawn from experiences by farmers and from investigations by the Missouri Agricultural Experiment Station are as follows:⁴

First, that tile drainage is especially profitable in the swales of the prairie region as well as in the bottom lands. Second, that while the tiles do not operate quite so efficiently on the tight level prairie as on the more open soils they will nevertheless yield good returns on most of this very flat prairie land. Third, on the more rolling prairie the use of tile does not usually seem profitable, except on seepy slopes or in draws, where it assists in preventing surface washing.

In general the yields range from 5 to 30 per cent higher on tilled land than on land not drained. In wet seasons these differences may be larger, and tiling is the determining factor between success and failure. The increasing value of the land will tend to make the tiling of the level prairie land an economic necessity.

The necessity of increased yields and of improvement in present methods is appreciated by the more intelligent farmers. Crop yields and farm income must keep pace with increasing land values, with the increasing cost of farm equipment, and with the necessities of life other than those produced on the farm. Greater income can be obtained only by increased crop yield and by greater economy in farm management. The present agricultural prominence of the county, after all, should perhaps be ascribed to the natural productiveness of the soil rather than to the application of the principles of scientific agriculture.

Under the present system of rather extensive agriculture, increasing the yields must probably be accompanied by more intensive methods, particularly in the matter of fertilization. To make this possible there may have to be a reduction in the cultivated area, for it is generally more economical to produce large yields on a small acreage than to have only moderate yields on a large acreage. The quantity of manure available could be used more efficiently on a smaller area and more land would be available for pasture. It is probable that the average cultivated area could be reduced 10 to 25

⁴ Missouri Agricultural Experiment Station Bulletin No. 118, Drainage Investigations on the Northeast Missouri Prairie.

per cent without reducing the total production, provided the reduced area of cultivated land would receive such manurial treatment as to make possible larger yields. It is probable that the present crops might be grown on four-fifths the area now devoted to them, and at a smaller expenditure of time, labor, and money; and therefore it would be better to abandon the least productive one-fifth of each farm and use it for pasture and to transfer to the other four-fifths the labor and energy that is now being spent in going over land that can not by any possibility produce full yields. The present average yield of corn of approximately 28 bushels, if increased by 5 bushels per acre, would permit a reduction of the total acreage by almost 26 per cent without a reduction in the total yield of the county.

SOILS.⁵

The parent materials of the upland soils of Knox County are mainly loess and glacial drift, known geologically as the Kansan till or drift. The basal rocks over most of the county consist of a moderately cherty, high-calcium limestone of Mississippian age. It is only in the deeper valleys in the southeastern part of the county that this limestone is exposed, giving rise to the Crawford soils. The residual soil material is characterized by brown to red color. In the western part of the county the basal formations consist of shales and sandstones of Carboniferous age, but these are buried so deeply that they exert no influence upon the soils.

The glacial material consists of a heterogeneous mass of sand, silt, and clay. Its formation and accumulation were due to the grinding and mixing action of the glacier passing over rock surfaces and the transportation of the material to the point of deposition. So great in extent was this mass of material and so powerful were the agents of distribution that the resulting glacial deposits cover not only Knox County but practically all of northern Missouri. The fine-grained material, such as the clay, silt, and fine sand is of both local origin from the underlying shales and sandstones and to a lesser extent from limestone, and of foreign origin from the rocks of northern regions. The shallower drift contains a much larger proportion of the underlying residual material than the deeper deposits. The fact that the underlying limestone was not incorporated to any great extent in the drift explains, at least in part, why the glacial deposits of this region are less calcareous than those in the western part of the State. The coarser material, such as the gravel and boulders in

⁵ Knox County adjoins Macon County on the southwest. In certain cases the maps of these counties do not seem to agree along the boundaries. This is due to changes in correlation resulting from a fuller understanding of the soils of the State. The Putnam silt loam in Macon County has in this area been in part subdivided into the Grundy silt loam and the Edina silt loam and a part of the Shelby loam is now regarded as Lindley loam.

the drift, is predominantly of northern origin. In general, the drift of this region is not as deep and contains a larger proportion of local material and less lime and coarse material than in the northern and western part of the State.

The thickness of the drift is quite variable, ranging from less than 5 to more than 30 feet. The average depth may be roughly estimated as somewhat less than 20 feet. The deposit averages thickest in the northwestern half of the county and thinnest in the southeastern half.

The glacial deposit has been acted upon by the various agencies of weathering. Erosion has modified the surface, so that it is everywhere rolling to hilly. The surface layer of the drift has been modified also by leaching and oxidation and the carrying away in suspension of the finer particles of earth, leaving a yellow to brownish-yellow sticky, sandy clay, with an accumulation of sand at the surface. The brown coloration in the upper portion of the till is due to the higher degree of oxidation of the iron there than at greater depths. Weathered exposures are usually very crumbly, and in fresh excavations the material may be very fine and heavy, but it never approaches a compact or impervious condition. It is this modified drift which gives rise to the Shelby and Lindley soils.

Originally the glacial drift was covered by a mantle of fine earth, with a probable depth of 3 to 10 feet, generally considered to be loess. As a result of erosion this mantle has been removed from the surface, except on the smooth upland areas and narrow watershed ridges. Similar material is encountered on the terraces along the larger streams.

This mantle of fine earth has given rise to the typical prairie soils of this region. The distinctive features of these soils, however, are the result of changes brought about since the deposition of the material by such agencies as erosion, oxidation, drainage, and vegetation, rather than the result of any difference in the original deposit. Through leaching processes the finer soil particles have been carried down below a depth of 12 to 20 inches, so that the prairie soils are characterized by silty surface soils and clay subsoils.

Three main series, Putnam, Edina, and Grundy, have been made to include all the prairie types. The series differentiation is based mainly on the color of the soil and the compaction of the subsoil. These features merely express the stage that has been reached in the cycle of changes that are brought about by weathering under the conditions existing in this region. On the extensive level uplands there has been the greatest change in depth and composition of the silty stratum. In such locations there has been a greater concentration and compaction of the clay in the subsoil, so that this zone is usually a stiff clay loam, not quite so favorable to good moisture

conditions as if the structure were more friable. The light color of the silty surface soil is due to lack of organic matter. The coloration of the subsurface is determined chiefly by the poor drainage conditions. Soil of this character has been included in the Putnam series.

On the gently undulating prairie land there has been least change in depth and composition of the silty stratum, and the subsoil is not as compact. Here there has been a greater accumulation of organic matter, giving the surface soil a darker color. Soil of this type has been included in the Grundy series. Between the Putnam and Grundy there are all variations, so that it frequently is difficult to distinguish between them. Thus the Edina silt loam is an intermediate stage, one in which the black color has not yet been destroyed, but the gray subsurface color has been developed. It is probable that the total quantity of mineral plant food is somewhat higher in the 3-foot section of the Edina than in the more thoroughly leached Putnam soil. This is the case with regard to lime, and doubtless is applicable in some measure to other essential plant-food minerals. All the prairie types respond to the addition of organic matter, indicating that the silty mantle as a whole is comparatively rich in mineral plant food.

Forests have invaded the prairie soils in small areas and changed them materially. The organic matter has become so reduced that the soil has a gray color and the subsoil is compact. There has been a segregation of the iron content, so that small concretions are abundant. Soil of this type has been classed in the Marion series.

In general, all the level and gently rolling upland originally was prairie, on which a vegetation consisting of grasses prevailed. It was during the prairie stage that the black humus accumulated, and in greater quantity than in the timbered areas. Most of the humus is in an advanced state of decay and is chiefly in the form of carbonaceous material. It is doubtless less active as an element of soil fertility than the humus which has resulted from the decay of plant remains in more recent times. This is further indicated by the better physical structure of the soil where the humus content is higher than on the older and lighter-colored prairies. As the natural drainage improved the lime was removed, and for much of the prairie land the percentage is so low as to affect unfavorably the productiveness of the soil. In general those soils best supplied with lime also contain the highest content of humus.

Somewhat similar conditions prevail on the terraces or second-bottom soils as on the prairies. The dark-colored type belongs to the Chariton series and the light-colored type to the Robertsville series.

The alluvial soils consist of material washed from both the glacial deposit and its silty covering. The latter has doubtless contributed the more on account of its greater surface exposure. With few ex-

ceptions the alluvial soils are remarkably light in color—lighter than normally prevails in soils with a high content of humus, the prevailing color being dark gray. This is undoubtedly due to the prolonged overflows followed by long periods of good drainage, which condition favors the rapid decay of the organic matter. Notwithstanding their light color, these soils are very productive. The dark-colored types have been classed in the Wabash series and the light colored in the Waverly series.

The table below shows the actual and relative extent of the various soil types:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Shelby loam.....	44,928	23.5	Marion silt loam.....	4,032	1.2
Brown phase.....	32,320		Lindley silt loam.....	3,520	1.1
Grundy silt loam.....	44,480	21.2	Clarksville silt loam.....	3,008	.9
Shallow phase.....	25,216		Wabash silty clay loam.....	2,880	.9
Putnam silt loam.....	52,544	16.0	Wabash clay.....	2,496	.8
Lindley loam.....	32,704	9.9	Robertsville silt loam.....	1,856	.6
Wabash silt loam.....	4,544	9.0	Wabash fine sandy loam, brown phase.....	1,216	.4
Brown phase.....	25,152		Edina silt loam.....	768	.2
Edina silt loam.....	19,072	5.8	Crawford stony loam.....	320	.1
Wabash loam.....	12,480	3.8			
Chariton silt loam.....	8,960	2.7			
Waverly silt loam.....	6,464	1.9	Total.....	328,960

PUTNAM SILT LOAM.

The surface soil of the Putnam silt loam to a depth of 8 to 10 inches is a gray to dark-gray, mellow silt loam. The lighter color prevails on the level and more poorly drained areas, and the dark color where the surface drainage is good. The subsurface stratum consists of light-gray silt loam. It varies from 2 to 8 inches in thickness and is thinner on the sloping and thicker on the level areas. It is usually somewhat heavier in texture than the surface soil, but is ashy in color and friable in structure when typically developed. This gray subsurface layer is always present and is one of the salient characteristics of the type. The true subsoil, which begins abruptly at a depth of 16 to 18 inches, consists of a drab to dull-brown heavy plastic clay, changing to brownish-gray, moderately friable clay loam, mottled with yellow and gray in the lower part of the 3-foot section. As a whole, the subsoil shows considerable compaction and is pervious to water in only a moderate degree.

In general, the Putnam silt loam of this region is somewhat darker in color and slightly more productive than the same type found in the counties to the south. It is closely related to the Grundy silt

loam, and its separation from the latter is more or less arbitrary. Mainly on account of the level surface and poor surface drainage, there has been a greater concentration of fine material and compaction in the subsoil, and the consequent poor underdrainage has resulted in the development of the gray subsurface horizon.

The Putnam silt loam occupies the broad, level, interstream prairies in the southern and eastern parts of the county. The land is ideally suited to the use of heavy farm machinery and is usually divided in large fields, about 40 acres. All the type is highly improved. Corn and oats are the principal crops, and timothy is extensively grown for both hay and seed. Practically all the type is more or less acid. On much of the land clover does not grow well, but this condition could probably be corrected by the use of lime or ground limestone, and in some cases by applying manure. The ordinary yield of corn is between 30 and 45 bushels per acre. Wheat yields from 15 to 20 bushels per acre when commercial fertilizers are used. Oats yield from 20 to 50 bushels, depending largely on the season. On account of the inadequate drainage of most of the type, there are occasional crop failures, particularly in wet seasons. Tiling should prove profitable on all the level, poorly drained areas.⁶

Continuous cultivation, and especially the continuous growing of corn, has greatly reduced the organic matter content of the soil. Moreover, the organic matter present seems to be in a finely divided state and in an advanced stage of decay. The soil therefore has a tendency to "run together" and be cloddy when cultivated, except under the most favorable conditions. There is need of adding more organic matter to the soil in the form of stable manure or green manures or of turning under sod once every four to six years.

The Missouri Agricultural Experiment Station has for many years been conducting experiments on the Putnam silt loam at several localities in northeast Missouri. The results of these experiments have been published in a station bulletin, to which the reader is referred.⁷

GRUNDY SILT LOAM.

The surface soil of the Grundy silt loam is a black to very dark brown or dark-gray silt loam, with an average depth of about 12 inches. The subsurface down to about 16 to 18 inches is normally a brown or dark-drab heavy silt loam. It is in most places somewhat heavier in texture than the surface soil, especially in the more rolling areas where the surface soil grades more quickly into the heavy subsoil. The color of this stratum varies from dark brown to

⁶ Missouri Agricultural Experiment Station Bulletin No. 118.

⁷ Missouri Agricultural Experiment Station Bulletin No. 126, Soil Experiments on the Level Prairies of Northeast Missouri.

dull gray; as a rule, it becomes lighter with depth and is lightest in the more nearly level areas where the subsurface is of greatest thickness. The subsoil below 18 to 20 inches is a dark-drab silty clay or clay loam, which changes to friable silty clay, mottled brown and yellow, in the lower part of the 3-foot section. The content of clay increases with increase in depth, but the material is not compact as in the flat prairie land. The transition into the heavy subsoil is gradual, extending through several inches. The subsoil is more pervious to water than the corresponding horizon in the Putnam silt loam.

On many of the slopes where erosion is active the surface soil is shallow and the clay subsoil may come to the surface as "clay points" or "scalds." In such places, too, the surface soil is notably lighter in color than elsewhere, and is more difficult to cultivate. In general, the soil of this type is deeper, darker, and of somewhat greater productiveness in the northern part of the county than in the southern half.

The Grundy silt loam is one of the most extensive types and is found in all parts of the county. It occurs as belts of varying width between the rolling glacial soils on the one side and the level prairie on the other side. All the type is highly improved and constitutes some of the best upland soil in the county. Corn is the most important crop, although the small grains, grasses, and clovers do well. The crops suffer less from poor drainage than on the Putnam silt loam and the yields average higher.

The soil is fairly well supplied with nitrogen but is deficient in phosphorus as indicated by analysis and by the response to fertilizer treatment. The greater part of the type shows a rather high lime requirement. However, clover grows fairly well, and because of this the humus content of the soil is easily maintained under the proper system of farming. Phosphatic fertilizers give profitable returns particularly if used on wheat.

Grundy silt loam, shallow phase.—The shallow phase of the Grundy silt loam differs from the typical Grundy silt loam mainly in the lighter color and shallower depth of the surface soil. The latter to a depth of 6 to 9 inches is a grayish-brown to dark-brown heavy silt loam, grading into dull-gray or brownish-gray heavy silt loam or silty clay. The subsoil below 15 inches is a drab or brown clay loam essentially like the typical Grundy silt loam. On slopes where erosion is active the heavy subsoil may lie near the surface or have only a thin covering of dark silty soil. In general, the subsurface is heavier in texture than the corresponding layer in the typical Grundy silt loam, and the subsoil is more mottled, more friable and not as plastic and stiff.

The shallow phase occurs most extensively in the southeastern part of the county, and is usually associated with the Putnam silt loam. It occupies the same topographic position as the typical Grundy, and is separated from the latter in a more or less arbitrary way. In its agricultural value the soil is inferior to the other Grundy soils, and a relatively larger proportion of it is used for grass.

In the management of this soil it is most essential to maintain and increase the organic matter content. A systematic rotation should be practiced in which legumes are grown every three or four years, primarily for soil improvement. Deep plowing is recommended to improve the structure of the soil, and on some of the more rolling places to prevent washing.

The Missouri Agricultural Experiment Station has been conducting an experiment field near Hurdland to determine the effect of various soil treatments. This field is located on the Edina silt loam in section 30, township 62 north, range 12 west, but the results obtained are believed to be applicable to the Grundy soils of this region.⁸ Plate I, figs. 1 and 2, shows some plots in these experiments.

EDINA SILT LOAM.

The surface soil of the Edina silt loam is a very dark brown to almost black mellow silt loam, which grades at an average depth of 9 to 12 inches into a grayish-brown or dark-gray silt loam, becoming lighter in color with increase in depth. The heavy subsoil begins at a rather uniform depth of about 18 inches, and is a brown to drab clay loam, which becomes somewhat friable, and usually is mottled brown and gray below a depth of 30 inches.

The chief soil differences between this type and the Grundy silt loam is the lighter color of its subsurface layer and the slightly greater compaction of its subsoil. The former is almost everywhere present and is a salient characteristic of the type. In general this soil is intermediate between the Grundy on the one side and the Putnam on the other. The character of the subsurface and subsoil are closely related to the Putnam, but the dark surface soil and the comparatively high productiveness are more like that of the Grundy.

This type is most extensively developed in the northwestern part of the county, where it covers the broad level prairie divides.

The Edina silt loam is used for the same crops, but has a somewhat lower agricultural value than the Grundy silt loam. It is not as well drained, and crops are more apt to suffer in wet seasons. All the soil is rather acid, and clover is grown with difficulty. Tile drainage and the use of ground limestone are some of the chief requirements for improving the soil.

⁸ Missouri Agricultural Experiment Station Bulletin No. 127, Soil Experiments on the Dark Prairies of Central and Northeast Missouri.

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

Mechanical analyses of Edina silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		<i>Per cent.</i>						
344504.....	Soil.....	0.2	1.5	0.5	1.3	4.4	69.9	22.0
344505.....	Subsurface.....	1.2	3.4	1.0	1.7	5.3	66.9	20.2
344506.....	Subsoil.....	2.6	3.6	1.3	3.3	4.3	50.3	34.3
344507.....	Lower subsoil...	.5	3.0	1.4	5.7	5.4	42.0	41.7

SHELBY LOAM.

The Shelby loam is a rather variable type. The surface soil ranges from a deep black loam to shallow grayish-brown loam, but normally is a very dark brown loam, with an average depth of 8 to 10 inches, changing to a brown loam, somewhat heavier and containing less sand than the surface soil. The shallower and lighter colored soil occurs mainly on the steeper slopes, where erosion is most active. The darker soil occurs on the moderately rolling land, at the base of slopes, and in places where the soil material contains a high percentage of lime.

The subsoil below 16 to 18 inches is a yellowish-brown heavy sandy clay loam, usually mottled in the lower part of the 3-foot section. A few small, rounded gravel are scattered through the soil and subsoil, but have little influence, except it be to give the material a more open structure. Lime concretions and calcareous streaks are abundant. In some places the dark surface soil grades directly into the heavy subsoil, but for the most part there is an intermediate zone of brown soil between the surface and subsoil. The latter shows little or no compaction, and in this respect differs from the level prairie soils.

The Shelby loam has a wide distribution. It occurs on all the rolling land where the glacial drift is exposed. The surface varies from gently rolling to rolling, and all the land is well suited to farming. The size of the fields in many places is limited by the presence of deep draws that can not be crossed with farm machinery.

The greater part of the type was originally prairie, or covered by a growth of hazel and other brush. All the land is highly improved. Corn and grass are the principal crops. Yields are probably a little larger than on most of the typical prairie soils. Many farmers consider the Shelby loam not well adapted to wheat, but for clover and bluegrass it is superior to the Putnam silt loam or level Grundy soils.

As indicated by the analysis, this soil is deficient in the three important plant-food elements, and is most deficient in phosphorus. The supply of potassium is considerably lower than in the Grundy soils.

In the management of this soil attention should be given to preventing surface and gully washing. On account of the sloping character of the land the washing away of the dark surface soil is frequently excessive. On all the longer slopes contour plowing or terracing is recommended. Turning under a sod once every four or five years is an effective way to prevent washing, and also adds the much-needed organic matter to the soil.

Shelby loam, brown phase.—The Shelby loam, brown phase, is closely related to the typical soil and differs from the latter mainly in the shallow depth and lighter color of the surface soil. It consists of a brown, dark-brown to grayish-brown loam, which becomes lighter in color and slightly heavier in texture with increase in depth. The subsoil is a yellowish-brown sandy clay like that of the typical Shelby loam. In general this soil is an intermediate type between the Shelby loam and Lindley loam. It averages slightly more rolling than the former, and therefore is subject to more severe erosion. The dark surface soil is constantly being removed and the yellow subsoil brought nearer the surface. Much of the land originally was forested, which accounts in part for the lighter colored surface soil. Also, the apparent relative lower percentage of lime has been unfavorable to the accumulation of a high content of organic matter.

A somewhat larger proportion of the brown phase is devoted to pasture than of the Shelby loam. The surface is moderately rolling, but numerous erosions frequently cut up the fields so as to make cultivation impracticable. In its inherent fertility the brown phase is equal to the darker Shelby loam, and with good management will produce as large yields. In its present condition the yields are somewhat lower. It is a good clover soil, but little is grown. Sweet clover is well adapted to the eroded areas, its deep roots opening the heavy subsoil. Areas that are traversed by many draws and gullies should be kept in pasture or other sods so as to reduce washing to a minimum. The greatest need of the soil is organic matter.

LINDLEY LOAM.

The soil of the Lindley loam is a brown to grayish-brown loam changing below to a yellowish-brown loam. It varies greatly in color and texture, depending upon the extent of recent erosion. In places the natural subsoil may be exposed, and this gives the surface a decidedly yellow color. When freshly plowed the soil appears yellow

or brownish yellow, but when it becomes dry after rain, it has a grayish color. On some of the gentler slopes the surface is almost a silt loam, but on all rolling areas it is a distinct loam in texture. In general, however, the type contains less sand and gravel than the corresponding type of the Shelby series.

The subsoil consists normally of a yellow or brownish-yellow clay loam or sandy clay. The upper part of the subsoil is in most places brown in color, and a clay or silty clay in texture, but this quickly passes into the characteristic yellow glacial till. The lower subsoil is usually moderately friable, and has brown and yellow mottlings. A few gravel and lime concretions are scattered through the soil mass.

The type occurs in all parts of the county, but is most extensive to the north of Knox City. It occupies the same relative topographic position as the Shelby loam, but the surface is much more steeply rolling. The slopes are usually short but steep, and at the higher elevations are completely dissected by numerous small short draws. The majority of the type is not too broken to be cultivated, but on account of the danger from severe erosion, the land is best suited to pasture and is mainly used for that purpose. The original vegetation consisted of oak and hazel brush. A small proportion of the land remains in forest, and where the growth is not too dense provides excellent pasture.

The only cultivated crop is corn, but the yields are low except in favorable seasons. Bluegrass and the clovers do remarkably well. Probably the best legume for this type of soil is red clover. On soil deficient in organic matter, but high in lime, sweet clover grows better than almost any other legume, and the fact that it is a very deep-rooting plant makes it of value in increasing organic matter and preventing washing. Slopes that have been ruined by washing may be made profitable as pasture by sowing this clover. The nitrogen supplied by the legume will also improve the growth of bluegrass.

LINDLEY SILT LOAM.

The soil of the Lindley silt loam is a gray to grayish-brown silt loam to a depth of 5 to 6 inches, grading below into yellowish-brown heavy but friable silt loam. Frequently the subsurface is a dull-gray or light-yellow silt loam, but it is not ashy in appearance and structure, like the corresponding layer in the Marion silt loam. The subsoil below 15 to 16 inches consists of a pale-yellow to yellowish-gray heavy, compact silty clay or clay loam, in most places friable and mottled with gray in the lower part of the 3-foot section. In places the subsoil is a drab clay loam somewhat like the subsoil of the Putnam silt loam.

The type occurs in two general topographic positions—on gentle slopes and divides within the region of the Lindley loam and as low gentle slopes in the region of the prairie soils. In the former position the type has a yellowish-brown subsurface and a light-yellow subsoil. More or less fine sand is mixed through the soil, indicating that it is essentially like Lindley loam in origin. The soil on the gently sloping areas is somewhat like the Putnam, but has acquired a gray color on account of the forest covering.

This is not a strong soil. It has about the same agricultural value as the Lindley loam. The soil is low in organic matter, but when this is supplied in the form of manure fair yields are obtained. The land is mainly used for pasture and hay production, to which uses it is best adapted. Bluegrass and clover grow well.

MARION SILT LOAM.

The Marion silt loam is the principal soil of the post-oak ridges. The surface soil is a gray or ash-colored silt loam, rarely more than 6 inches in depth. The subsurface is a light-gray to almost white silt loam, containing small, black iron concretions. This gray layer is almost always present. It is best developed in the flat areas, and is thinnest in the rolling land or where the type grades into some other soil. The true subsoil begins rather abruptly at a depth of 16 to 18 inches and consists of a gray or drab heavy, stiff clay, mottled yellow and somewhat friable below 30 inches. Both the subsurface and the heavy subsoil are slowly pervious to water and are therefore locally referred to as "hardpan."

The Marion silt loam occurs mainly in the northeastern part of the county. It occupies the narrow divides or ridges, having the same topographic position as the Grundy silt loam. The surface is level or nearly so, and the surface drainage is usually good. The characteristic vegetation is post and white oak. The majority of the type is cleared and, with the associated Lindley soils, is largely used for pasture. The yields of corn are small and rarely profitable without the use of manure or fertilizer. Red clover does not grow well. For the improvement of the soil the liberal use of ground limestone to correct the acidity, and of manure and phosphates is of chief importance.

CLARKSVILLE SILT LOAM.

The surface soil of the Clarksville silt loam is a gray to yellowish-gray silt loam 6 to 7 inches deep. The layer grades quickly into pale-yellow or yellowish-brown silt loam, which becomes heavier with depth and at about 12 inches is typically a heavy silt loam or friable silty clay. The subsoil at 15 to 18 inches is a drab or pale-yellow heavy, stiff, compact clay. It changes downward to gray clay and in



Photo from the Mo. Agr. Expt. Sta.

FIG. 1.—WHEAT PLOTS ON THE HURDLAND EXPERIMENT FIELD. THE SOIL IS THE GRUNDY SILT LOAM.

The results of the experiments at this station will be of especial value to farmers on this type of soil, not only in Knox County, but also in all this part of Missouri. To make possible the tying of experimental results to the particular type of soil is a fundamental idea of the soil survey.

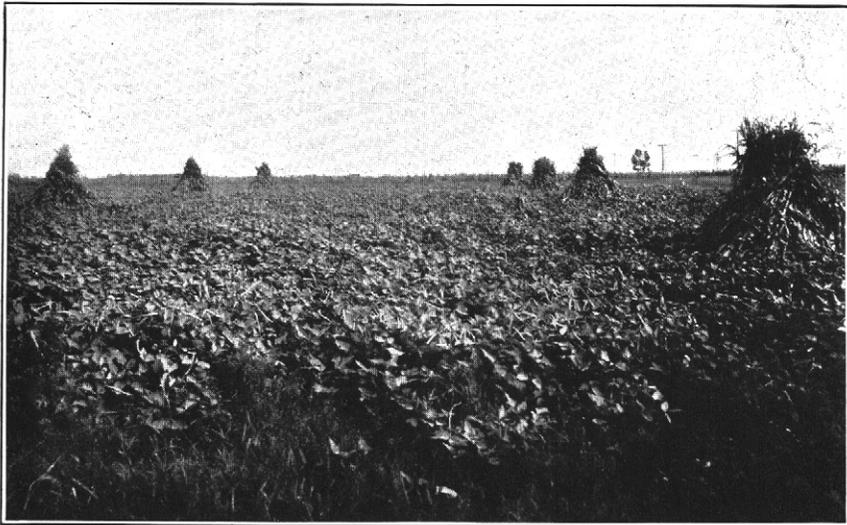


Photo from the Mo. Agr. Expt. Sta.

FIG. 2.—COWPEAS IN CORN ON GRUNDY SILT LOAM.

Note level topography. There are 44,000 acres of typical Grundy silt loam and 25,000 acres of the shallow phase of this type in Knox County.

the lower part of the 3-foot section is a gray silty clay mottled yellow and brown. A few small chert fragments are scattered through the soil mass.

The immediate surface soil is gray so that cultivated fields have a characteristic gray appearance. On the lower slopes, especially where the bedrock lies near the surface, the soil is light brown or yellow in color and the subsoil rather friable. This brown variation is somewhat more productive than the typical soil. On a few small flat areas the type somewhat resembles the Marion silt loam.

The Clarksville silt loam occurs in the southeastern part of the county along South Fabius River. It occupies long gentle slopes and is well suited to cultivation. The soil is derived mainly from the local limestones, but shales and glacial material also have entered into the composition. Originally the Clarksville silt loam was heavily timbered with oak, hickory, and walnut. The greater part of the land is now used for pasture and the production of hay. It is a good bluegrass soil and will grow clover well. Corn is grown and on manured fields gives yields of 30 to 45 bushels per acre. As a wheat soil it is superior to the glacial or prairie soils, as the plants do not winterkill as readily. In general, the type is best suited to grass and corn. A rotation of these crops with wheat and clover, and with three or four years between corn crops, is probably the most practical way of handling the soil. Land values at the time of the survey ranged from \$45 to \$60 an acre.

CRAWFORD STONY LOAM.

The Crawford stony loam includes the narrow bands of stony land and rocky cliffs along South Fabius River. In general, these areas are less than 6 rods in width, and on account of the steep slopes and numerous rock outcrops are nonagricultural. The soil material is rather variable, but usually consists of a dark-brown to grayish-brown silt loam, underlain by reddish-brown clay loam subsoil.

CRAWFORD SILT LOAM.

The soil of the Crawford silt loam is a rather uniform grayish-brown to reddish-brown mellow silt loam, grading at about 15 to 18 inches into light-brown friable silty clay, with thin gray streaks or cleavages. The lower subsoil shows a few black iron stains. The immediate surface soil is usually a dull gray, but where erosion is active the reddish-brown color prevails.

The type occurs as narrow belts along South Fabius River, and is generally associated with narrow outcrops of stony loam. The soil is derived from pure limestone, and represents the youngest upland soil in the area. Originally it was timbered with walnut, elm, and oak.

This is a very productive soil, used mainly for corn and grass. Clover, alfalfa, and small grains make a strong growth. On account of its small extent, it is usually farmed with the adjoining upland type.

CHARITON SILT LOAM.

The Chariton silt loam consists of a gray to dark-gray silt loam, underlain at a depth of about 10 to 12 inches by light-gray or ashy silt loam that extends to a depth of about 18 to 20 inches. The subsoil is a drab to light-brown, heavy, plastic clay, changing at about 30 inches to moderately friable silty clay, mottled brown and gray. The gray subsurface horizon is characteristic of the type, although it varies in thickness from 2 to 8 inches.

In general appearance of the soil profile and in productivity this soil is very similar to the Putnam silt loam. Where the type is crossed by small draws from the upland, more or less soil has been deposited, and such places usually have a deeper and darker surface soil than the average of the type.

The Chariton silt loam forms the second bottom or terrace land along the larger streams. All of it lies above overflow. It is generally separated from the first bottom by a distinct rise or bench from 3 to 10 feet high. The surface is level or has a very slight slope toward the stream channel.

This is essentially a prairie soil. It is highly improved, and when farmed in the same way as the Grundy soils the yields are about the same. The greatest needs of the soil are organic matter and lime. The content of phosphorus is low, and good returns follow the use of this element in fertilizers. Many of the poorly drained areas could be improved by tiling and ditching. Clover will not make a good growth on the light-colored areas, unless the acidity of the soil is corrected. In general, the soil treatment recommended for the Putnam silt loam applies also to this type.

ROBERTSVILLE SILT LOAM.

The Robertsville silt loam is locally known as "white-ash land." The soil to a depth of 8 to 10 inches consists of a light-gray to yellowish-gray silt loam, passing into an ashy gray heavy silt loam containing many small roundish concretions. The subsoil is usually a compact gray or drab clay, mottled gray and yellow in the lower part. Near the outer edges of the areas the gray subsurface layer may be wanting and the subsoil more friable.

The type has the same topographic position as the Chariton silt loam, and the origin of the two soils is the same. On account of the forest covering, only a small amount of organic matter has accumu-

lated in the soil. Post oak and white oak are the principal trees. The surface drainage is good, but the compact subsoil is almost impervious to water and air, and hence the type is rather poorly drained and cold.

On account of the rather low fertility of the soil profitable crops are rarely obtained without the use of manure. In order to grow clover successfully, it will be necessary to apply 1 to 3 tons of ground limestone per acre, as the soil is decidedly acid. Most of the type is used for pasture and for mowing land.

WABASH FINE SANDY LOAM, BROWN PHASE.

The Wabash fine sandy loam, brown phase, occurs in small areas in various parts of the county. The soil is predominantly a brownish-gray fine sandy loam changing at a depth of 7 to 12 inches into light-gray or light-brown fine sandy loam, relatively high in clay. In the lower subsoil brown mottlings and a few small concretions are found. In general, the soil material is rather uniform throughout the 3-foot section. It is sandier near the streams than along the edge of the upland.

All of the type is subject to deep overflow, and therefore much of it remains in forest or is in woods pasture. Cleared areas are used for corn, of which good yields are obtained. Cucumbers, melons, and other truck crops do well.

WABASH LOAM.

The Wabash loam represents the narrow belt of soil, both alluvial and colluvial in origin, bordering most of the draws and branches and in places some of the larger streams. The type is quite variable in color and texture, but normally is a black, dark-brown, or grayish-brown loam to sandy loam. In the more rolling sections where washing is more marked the soil is generally quite sandy, while in the gently rolling regions the sand content is relatively low. The subsoil is somewhat heavier in texture and slightly lighter in color than the surface soil, and in most places consists of dark-brown loam or clay loam. The Wabash loam is one of the most fertile and easily worked soils in the county. It lies somewhat higher than the other bottom-land types, and is rarely overflowed. Its structure allows rapid percolation of water and the drainage conditions are good. It is well suited to all the field crops, but particularly to corn and grass, and, where underdrainage is good, to alfalfa. In some of the narrow valleys the meanders of the stream channel make impracticable the cultivation of the land, and in such places it is generally used for pasture.

WABASH SILT LOAM.

The Wabash silt loam consists of black or very dark-brown heavy silt loam, gradually becoming heavier in texture with increase in depth, and at about 15 to 18 inches changing to a dark-drab silty clay. There are many variations from the normal. While the surface soil is generally a heavy silt loam, it may be a loam. There may be little change in color or texture in the whole soil section of 36 inches. In some places the subsurface is a dark-gray silty material and the subsoil a heavy drab clay. In general the soil is much darker in color, heavier in texture, and harder to work, though more productive, than the lighter colored brown phase of the type, a description of which is given below. Both typical soil and phase are well supplied with organic matter.

The Wabash silt loam occurs in the larger stream valleys, in those positions where the adjoining upland glacial soil contains a relatively high content of lime, and the leaching and washing of this material into the bottom, together with the organic matter, has given the soil the dark color. Most of the type is subject to occasional overflow. It is one of the strongest soils in the area, and is highly prized for the growing of corn and grass. The productiveness of the land is maintained by deposits from overflows.

Wabash silt loam, brown phase.—The surface soil of the Wabash silt loam, brown phase, varies from dark-brown to dark-gray mellow silt loam, changing at a depth of 9 to 15 inches into light-gray to brownish-gray silt loam. The lower subsoil below 24 to 30 inches is normally a dark-gray, friable, silty clay, frequently containing brown stains and small concretions. The surface soil on the average is deeper and darker in color in the smaller valleys and where it receives deposits from lateral drainage. There are included in the phase small areas of Wabash loam and Waverly silt loam. In general, the soil is not as dark in color and is not quite as productive as the typical Wabash silt loam in the northwestern part of the State.

Compared with other bottom-land soils the Wabash silt loam, brown phase, is only moderately productive. Although only a small part remains in forest, mainly along the stream banks, much of the land, on account of poor drainage, is used only for permanent pasture. Timothy and corn are the cultivated crops. Yields of the latter range from 30 to 60 bushels per acre. Well-drained areas will grow clover and probably alfalfa.

Practically all the phase is subject to prolonged overflow. This condition not only results in the occasional loss of crops but also seems to have an injurious effect on the soil itself. Although fairly well supplied with organic matter, the soil has that cold, lifeless appearance often noticed in poorly drained and aerated types.

The important step in the improvement of this type is drainage. This can be accomplished by straightening and enlarging the stream channels, by leveeing where practical, by constructing open lateral ditches, and by laying tile drains. Great improvement could be made by constructing ditches from the small upland streams to the main streams, thus preventing flooding of the bottom by the laterals. Tiling, too, would be effective, but this ought to be preceded by deepening and straightening the main stream. With improved drainage bluegrass would do much better and mowing sods would not deteriorate so quickly.

WABASH SILTY CLAY LOAM.

The surface soil of the Wabash silty clay loam is a black to very dark gray silty clay loam containing a good supply of organic matter. The subsoil is a heavy black or dark-drab silty clay or clay, continuing to a depth of 3 or more feet.

The type occurs along South, Middle, and North Fabius Rivers and occupies a position slightly lower than the Wabash silt loam. Much of it was originally poorly drained, and in this condition accumulated a large amount of organic matter from the wild grasses growing in such places. It is used largely for corn, and yields of 60 to 70 bushels per acre are obtained in favorable seasons. Most of the type is subject to overflow, and crops are sometimes lost. Tiling the land would not only improve the workability of the soil, but would remove the water more rapidly after overflows. Fall plowing and the addition of organic matter would also tend to make the soil more friable.

WABASH CLAY.

The Wabash clay is locally known as "gumbo." The surface soil is a deep, black silty clay or clay loam containing a high percentage of organic matter. The subsoil is a black or dark-drab, heavy, plastic clay becoming lighter in color with increase in depth. The lower subsoil is sometimes faintly mottled with brown and yellow.

The type occurs in the larger bottoms, and occupies the lower, back-water areas, where the finest material in suspension has settled. The surface is slightly lower than of the surrounding bottom types. The drainage of the soil is poor, and during wet seasons the areas are frequently covered with water. With improved drainage the soil partially loses its waxy character. The property of shrinkage is highly developed, and in times of drought results in the formation of large cracks, which injure the crops by breaking the roots. The cracks attain a width of 2 to 4 inches, and extend to a depth sometimes of 2 feet or more. The soil is difficult to plow or cultivate, because it puddles when wet and breaks into clods when dry.

The first requirement for the improvement of this soil is thorough drainage. This usually can be easily accomplished by tiling or by constructing open ditches. The use of lime and organic matter will tend to improve the tilth. No other treatment is likely to prove profitable. The soil is very productive. Large yields of corn are obtained in favorable seasons. Much of the land is used for pasture and is covered with coarse grass.

WAVERLY SILT LOAM.

The Waverly silt loam is locally known as "white land" or "gray bottom" on account of its characteristic light color. The surface material to a depth of 5 or 8 inches is a light-gray to gray silt loam, underlain by an almost white powdery silt loam. The latter material extends to a depth of 24 to 30 inches, where it changes to a dark-gray to drab friable silty clay, mottled with brown in the lower part. This lower heavy subsoil, although not compact, seems to be rather impervious, owing probably to cementation with iron salts. This is particularly true of the higher bottoms, which are not receiving new material and are assuming the characteristics of the Robertsville silt loam. In such places the surface soil is lighter in color and the subsoil is more compact. Small concretions are scattered through the soil mass.

Along the stream banks the soil is usually a brown silt loam and is more productive than the typical soil. In fact, that part of the type known as "timber bottom" usually contains some fine sand and has a mellow soil and a subsoil less compact than in the "prairie bottom." On some of the wide, poorly drained bottoms the surface soil is dark gray and consists of recent alluvium.

The Waverly silt loam occurs mainly in the southern part of the county, within the region of the level prairies, where the stream valleys are wide and poorly drained. Overflows are frequent and sometimes have a duration of three to five days. On account of this condition, and because much of the soil material is derived from the upland gray prairies, the soil is light in color and is leached. Where the soil material is largely washed from glacial till, the bottoms are usually darker in color.

The type represents both prairie and timber bottoms, the former occurring only in the larger valleys. Much of the land is still forested and is used largely for pasture. Poorly drained areas support a growth of coarse grasses. Bluegrass does fairly well, particularly on the higher land, but most of the pastures are rather weedy. Timothy is extensively grown and is one of the best crops for the soil. Corn is an important crop, but requires favorable seasons for good

yields. Wheat is an uncertain crop under present drainage conditions, but should do well on areas improved in this respect. In general this soil offers great opportunities for improvement.

The soil is rather low in organic matter, but its greatest need in the way of amendment is lime to correct the acidity. In the improvement of the drainage, the means recommended for the Wabash silt loam may be employed.

SUMMARY.

Knox County, Mo., is located in the prairie region of the northeastern part of the State. It includes an area of 514 square miles, or 328,960 acres.

The surface features of the county vary from level prairie to rolling timberland. The former includes the extensive broad, level to gently rolling, interstream divides or prairies. The rolling land occurs in belts varying from one-half to 2 miles in width, bordering the streams. All the land is well suited to cultivation, and practically all of it is farmed. The county has a population of 12,403 and contains 2,041 farms.

The average annual temperature is 53.4° F., and the average annual precipitation is 38.75 inches.

The agriculture of the county is of the corn-belt type, and is based on general farming combined with live-stock raising. Corn, oats, and grass are the important crops. A large part of each farm is devoted to pasture, although there are few permanent pastures in the prairie farms. Cattle, hogs, sheep, and horses in large number are raised and sold annually. The farm practices, in general, are good, but there is need of giving more attention to the growing of clover and to the use of manure and fertilizers to maintain and increase the productiveness of the soils.

The upland soils are derived mainly from glacial and loessial material, either as laid down or as transported, reworked, and deposited by the streams. Four main groups of soils have been established—prairie, glacial, residual, and alluvial.

The prairie soils form the extensive level to gently rolling uplands. They have dark-gray to black surface soils and drab or brown heavy clay subsoils. They are classed with the Putnam, Edina, and Grundy series. The soil types, which are all silt loams, include much of the most valuable land in the county and are highly improved general farming soils.

The glacial soils are included in the Shelby and Lindley series. They have dark-brown to grayish-brown surface soils and yellowish-brown sandy clay subsoils. The Shelby loam is a good general farming soil. The Lindley soils are used mainly as pasture land.

The residual soils, derived from limestone, are the Clarksville silt loam and the Crawford silt loam and stony loam. The former is characterized by a gray color, while the latter are brown in color.

The alluvial soils include the Chariton, Robertsville, Wabash, and Waverly series. The Chariton and Robertsville silt loams are second bottom soils and closely resemble the gray prairie uplands. The first bottom soils are grouped in the Waverly and Wabash series. The former are gray and the latter dark in color. All are subject to overflow, but where well drained comprise some of the most productive land in the county. They are used largely in the production of corn and grass.



[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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