UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 23

DEKALB COUNTY SOILS

By J. G. MOSIER, H. W. STEWART, E. E. DE TURK,
AND H. J. SNIDER

PREPARED FOR PUBLICATION BY L. H. SMITH

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IN RECOGNITION

The Soil Survey of Illinois was organized under the supervision of the late Dr. Cyril G. Hopkins. The work progressed for eighteen years under his guidance and the first eighteen soil reports bear his name as senior author. On October 6, 1919, Dr. Hopkins died in a foreign land in the service of the American Red Cross. It is the purpose to carry on to completion this great work of the Illinois Soil Survey in the spirit, and along the same general plan and lines of procedure, in which it was begun.

INTRODUCTORY NOTE

It is a matter of common observation that soils vary tremendously in their productive power, depending upon their physical condition, their chemical composition, and their biological activities. For any comprehensive plan of soil improvement looking toward the permanent maintenance of our agricultural lands, a definite knowledge of the various existing kinds or types of soil is a first essential. It is the purpose of a soil survey to classify the various kinds of soil of a given area in such a manner as to permit definite characterization for description and for mapping. With the information that such a survey affords, every farmer or land owner of the surveyed area has at hand the basis for a rational system of improvement of his land. At the same time the Experiment Station is furnished an inventory of the soils of the state, upon which intelligently to base plans for those fundamental investigations so necessary for solving the problems of practical soil improvement.

This county soil report is one of a series reporting the results of the soil survey which, when completed, will cover the state of Illinois. Each county report is intended to be as nearly complete in itself as it is practicable to make it, even at the expense of some repetition. There is presented in the form of an Appendix a general discussion of the important principles of soil fertility, in order to help the farmer and land owner to understand the significance of the data furnished by the soil survey and to make intelligent application of the same in the maintenance and improvement of the land. In many cases it will be of advantage to study the Appendix in advance of the soil report proper.

Data from experiment fields representing the more extensive types of soil, and furnishing valuable information regarding effective practices in soil management, are embodied in form of a Supplement. This Supplement should be referred to in connection with the descriptions of the respective soil types found in the body of the report.

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SUPPLEMENT

DE KALB COUNTY SOILS

BY J. G. MOSIER, H. W. STEWART, E. E. DE TURK, AND H. J. SNIDER
PREPARED FOR PUBLICATION BY L. H. SMITH[1]

LOCATION AND CLIMATE OF DE KALB COUNTY

DeKalb county is situated in the northern part of Illinois about twenty-five miles south of the Wisconsin line and fifty miles west of Lake Michigan. It is approximately 36 miles long and 18 miles wide, and has an area of 632.7 square miles. About five-sixths of the county lies in the early Wisconsin glaciation, and the remainder in the Iowan.

The temperature of DeKalb county is characterized by a wide range between the extremes of summer and winter. The greatest range of any year since 1884 at Sycamore in this county was 125 degrees. The lowest temperature recorded was —28°; the highest, 106°. The average date of the last killing frost in spring is May 2; the earliest in fall, October 5. The growing season therefore is about 156 days long.

The average annual precipitation at Sycamore from 1882 to 1920 was 33.65 inches. The average rainfall by months for this period was as follows: January, 1.69 inches; February, 1.68; March, 2.54; April, 3.06; May, 4.18; June, 3.94; July, 3.34; August, 3.22; September, 3.38; October, 2.77; November, 2.11; December, 1.74. The percentage of total rainfall for each season is: winter, 15.1; spring, 29.2; summer, 31.3; autumn, 24.4. The year of heaviest rainfall on record was 1883, when the precipitation was 50.91 inches; the driest year was 1901, when the rainfall was but 21.35 inches.

AGRICULTURAL PRODUCTION

DeKalb county is primarily agricultural. Practically the entire county is made up of tillable land, a large percentage of which is prairie. In 1920 there were 2,400 farms having an average of 157.7 acres, 147.4 acres of which was improved land. Fifty-one percent of these farms were operated by tenants. This was a decrease of almost 2 percent in the last ten years.

The principal crops are corn, oats, spring wheat, pasture, hay, barley, winter wheat, rye, clover, and soybeans. The Fourteenth Census of the United States (1920) reports the following as the acreage and yield of the principal crops. It must be remembered that these figures are for but a single year, that of 1919.

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[1] J. G. Mosier, in charge of soil survey mapping; H. W. Stewart, in charge of field party; E. E. DeTurk, in charge of soil analysis; H. J. Snider, in charge of experiment fields; L. H. Smith, in charge of publications.

Crops	*Acreage*	*Production*
Corn	109,839	5,085,706 bu.
Oats	64,922	2,529,138 bu.
Wheat	47,330	933,640 bu.
Barley	10,852	299,257 bu.
Rye	2,183	44,836 bu.
Timothy	8,213	12,670 tons
Timothy and clover mixed	28,073	50,691 tons
Clover	2,115	3,617 tons
Alfalfa	838	2,127 tons
Silage crops	14,023	119,490 tons
Corn cut for forage	8,794	23,882 tons

The acreage of pasture is not given by the census, but from other data it is found to be approximately 67,000.

The live-stock interests, including those of the dairy, are of considerable importance, as is shown by the following data, also taken from the census of 1920.

Animals and animal products	*Number*	*Value*
Horses	17,720	$1,743,381
Mules	363	44,675
Beef cattle	32,945	2,392,679
Dairy cattle	18,252	1,337,833
Sheep	14,012	174,389
Swine	71,177	1,828,779
Chickens and other poultry	302,353	326,038
Eggs and chickens	......	670,115
Dairy products	......	949,757

The total value of the live stock and their products is nearly eight and a half million dollars.

Fruit growing is not very important. There were about 80,000 quarts of small fruits, 12,800 bushels of apples, pears, and cherries, and 90,000 pounds of grapes produced in 1920.

SOIL FORMATION

The most important period in the geological history of the county from the standpoint of soil formation was that during which the material that later formed the soils was being deposited. This was the Glacial period. At that time snow and ice accumulated in the region of Labrador, west of Hudson Bay, and in the Rocky Mountains to such an amount that the mass pushed outward from these centers, especially southward, until a point was reached where the ice melted as rapidly as it advanced. As the ice advanced in these movements it buried everything, even the highest mountains, in its path. It would then recede slowly, and apparently normal conditions would be restored for a long period, after which another advance would occur. At least six of these great ice movements took place, each of which covered part of northern United States, altho the same parts were not covered every time.

The names of the glaciers that have had some part, either directly or indirectly, in the formation of the soils of Illinois are as follows: (1) the Nebraskan, which did not touch Illinois; (2) the Kansan, which covered the western parts of Hancock and Adams counties; (3) the Illinoisan, which covered all of the state except the northwest county (Jo Daviess), the southern part of Calhoun county, and the seven southernmost counties; (4) the Iowan, which covered a part of northern Illinois, the area covered being difficult to determine because of the effect of the subsequent glaciations; (5) the early Wisconsin, which covered the northeast part of the state as far west as Peoria and as far south as Shelbyville; (6) the late Wisconsin, which extended to the west line of McHenry county and south to the town of Milford in Iroquois county.

In advancing from the distant northern centers of accumulation, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even large masses of rock. Some of these materials were carried several hundred miles, and the coarser masses rubbed against the surface rocks or against each other until largely ground into rock powder, which now constitutes much of the soil. When, thru the melting of the ice, the limit of advance was reached, the material carried by the glacier was dropped, accumulating in a broad, undulating ridge or moraine, called a lateral moraine if formed at the side of the glacier, and a terminal moraine if formed at the end. If the ice melted more rapidly than the glacier advanced, the terminus of the glacier would recede, and the material would be deposited somewhat irregularly over the land, back of the moraines. Such a formation is known as a ground moraine. A glacier often would advance again, but not so far as before; or it would remain stationary, and another moraine would be built up. These moraines or ridges have a steep outward slope and a very gradual inward slope.

A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets may have been hundreds or even thousands of feet in thickness. The materials carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed down, valleys were filled with the debris, and the surface features were changed entirely. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift.

THE GLACIATIONS OF DEKALB COUNTY

There were at least three ice advances that reached DeKalb county and covered it wholly or in part. The first was probably the Illinoisan glacier, which covered the entire county. This glacier melted and somewhat normal conditions were restored, as is indicated by the thick soil formed from the material deposited by it. This is known as the Sangamon soil.

The drift left by this glacier was buried by another ice sheet, the Iowan. Later the early Wisconsin glacier covered about five-sixths of the county. In this glaciation two morainal ridges were left which cross the county in a northeastern and southwestern direction. These ridges belong to the general Bloomington morainic system. The northern, or outer, ridge is broken thru at places by branches of the Kishwaukee river and is about one hundred feet higher than the general level of the district to the west. The southern, or inner, ridge is narrower and not so high as the outer ridge. The average depth of the drift in the county is about 150 feet. The greatest thickness of the drift, as determined in making wells, is 260 feet. Many large granite boulders are found on the moraines. Some of these are as much as eight feet in diameter.

The glaciers that covered DeKalb county left a deposit called till, glacial drift, or boulder clay (a mixture of boulders, gravel, sand, silt, and clay), but this deposit does not form the soil material except in small areas. The rock flour produced by the grinding action of the glaciers was reworked by the wind and deposited over practically all of the county to a depth of three to six feet. This loessial, or wind-blown, material has been transformed into soil by weathering and by the accumulation of organic matter, and now covers all the county except those places where it has been removed by erosion. There is little doubt but that this wind-blown material was fairly uniformly deposited over the exposed surface, but it has subsequently been removed in places by erosion, so that the boulder clay is exposed on some of the more rolling areas. The deposit is thicker on the Iowan glaciation than on the early Wisconsin, partly because of a deeper original deposit (3 to 6 feet), and partly because there has not been so much erosion on this less rolling area.

During the melting of the glacier the streams draining this area were frequently flooded, and the water carried large amounts of rather coarse material, such as gravel and sand. This was deposited in the valleys, partly filling them. Later the streams cut down thru the fill, leaving gravel terraces. This gravel was later covered with the fine material that now constitutes the soil. In the northeast township this flood water spread out over a large area, with the result that an extensive gravel plain was formed that reaches over into Kane and McHenry counties. Subsequent deposits of fine material on the surface of the gravel have aided in forming an excellent soil.

PHYSIOGRAPHY AND DRAINAGE

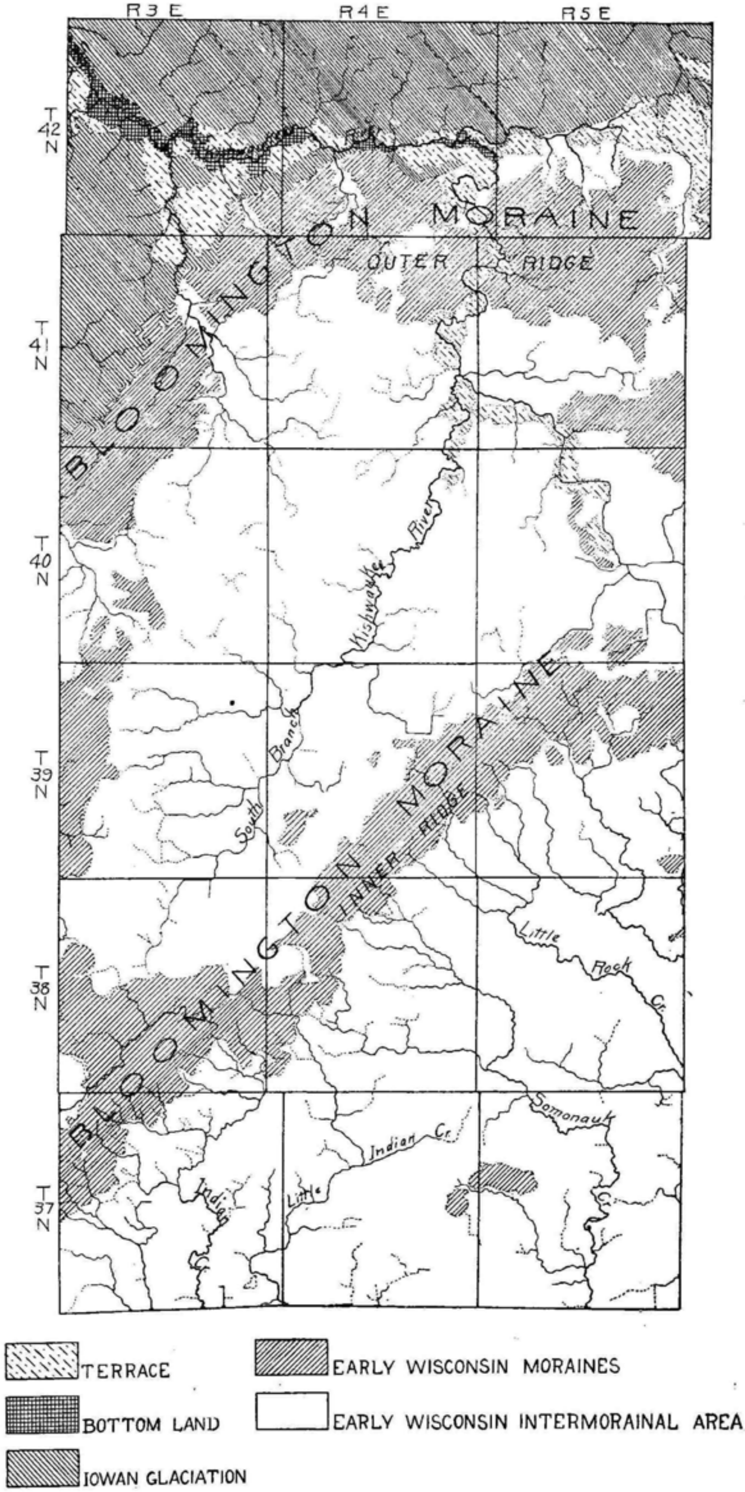
The county varies in topography from flat to slightly rolling. Even along the streams, hills do not exist to any extent. The principal variations are due to irregular deposition of glacial material. The moraines are characterized by an irregularly rounded, billowy topography, and they vary in width from three to six miles.

The southeast part of the county has a gradual slope to the Fox river, thru which this part is drained into the Illinois river. The northern two-thirds of the county is drained thru the Kishwaukee into the Rock river. Because of the flat character of the southeast part of the county, much tile draining has been done.

The altitudes of some places in DeKalb county are as follows: Carleton, 887 feet above sea level; Carleton Park, 855; Charter Grove, 875; Clair, 878; Cortland, 897; DeKalb, 886; Elva, 875; Esmond, 828; Fairdale, 787; Franks, 698; Genoa, 838; Hinckley, 740; Kingston, 795; Kirkland, 775; Lee, 939; Malta, 915; New Lebanon, 848; Rollo, 754; Sandwich, 667; Shabbona, 900; Shabbona Grove, 816; Somonauk, 690; Sycamore, 840; Van Buren, 740; Waterman, 820.

The highest altitude in the county, 955 feet, is found three miles north of Lee. Another high point occurs in the northwest part of Township 39 North, Range 5 East, which is about 940 feet.

In the terrace formation along the stream courses the soil is largely underlain by coarse material, such as sand and gravel, which provides favorable conditions for underdrainage.



Map Showing the Drainage Basins of DeKalb County with Morainal, Intermorainal, Terrace, and Bottom-Land Areas

SOIL TYPES

The soils of DeKalb county are divided into the following groups:

(a) Upland Prairie Soils, including the upland soils that have not been covered with forests and on which the luxuriant growth of prairie grasses has produced relatively large amounts of organic matter.

(b) Upland Timber Soils, including nearly all the upland areas that are now, or were formerly, covered with forests.

(c) Terrace Soils, including bench lands, or second bottom lands, formed by deposits from overloaded streams, and gravel outwash plains formed by broad sheets of water arising from the melting of the glaciers.

(d) Swamp and Bottom-Land Soils, including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

Table 1 gives a list of the types of soil found in DeKalb county classified according to the groups described above. It also shows the area of each type in square miles and in acres, as well as the percentage of the total area. For example, it may be noted that the brown silt loam, or rolling prairie land, occupies more than four-fifths of the county. The accompanying map shows the location and boundary of each type of soil, even down to areas of a few acres.

For explanations concerning the classification of soils and the interpretation of the map and tables, the reader is referred to the first part of the Appendix.

TABLE 1.—SOIL TYPES OF DEKALB COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (700, 900, 1100)			
-26	Brown silt loam	516.82	330,765	81.68
-25	Black silt loam	7.96	5,094	1.26
-20	Black clay loam	.23	147	.04
-60	Brown sandy loam	.12	77	.02
-90	Gravelly loam	.12	77	.02
		525.25	336,160	83.02
	(b) Upland Timber Soils (700, 900, 1100)			
-34	Yellow-gray silt loam	41.46	26,534	6.55
-35	Yellow silt loam	.43	275	.07
-64	Yellow-gray sandy loam	.10	64	.01
		41.99	26,873	6.63
	(c) Terrace Soils (1500)			
1527	Brown silt loam over gravel	15.37	9,837	2.43
1525	Black silt loam	1.53	979	.24
1536	Yellow-gray silt loam over gravel	4.98	3,187	.79
1566	Brown sandy loam over gravel	.14	90	.02
		22.02	14,093	3.48
	(d) Swamp and Bottom-Land Soils (1400)			
1450	Black mixed loam	22.24	14,233	3.51
1401	Deep peat	2.02	1,293	.32
1402	Medium peat on clay	.04	26	.01
1454	Mixed loam	19.10	12,224	3.02
		43.40	27,776	6.86
	(e) Miscellaneous			
	Gravel pits	.04	26	.01
	Total	632.70	404,928	100.00

INVOICE OF PLANT FOOD IN DE KALB COUNTY SOILS

SOIL ANALYSIS

The composition reported in the accompanying tables is, for the more extensive types, the average of several analyses. These analyses show that soils, like most things in nature, are variable; but for general purposes the average may be considered sufficient to characterize the soil type.

The chemical analysis of a soil, obtained by the methods here employed, gives the invoice of the total stock of the several plant-food materials actually present in the soil strata sampled and analyzed, but it should be understood that the rate of liberation, as explained in the Appendix (page 26), is governed by many factors.

For convenience in making practical application of the chemical analyses the results have been translated from the percentage basis and are presented here in terms of pounds per acre. In this, the assumption is made that for ordinary types a stratum of dry soil 6⅔ inches thick weighs 2,000,000 pounds. It is recognized that this value is only an approximation, but it is believed that it will suffice for the purposes intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires for any purpose to consider the information in that form.

THE SURFACE SOIL

In Table 2 are reported the amount of organic carbon (which serves as a measure of the organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium contained in 2 million pounds of the surface soil (the plowed soil of an acre about 6⅔ inches deep) of each type in DeKalb county.

Because of the extreme variations frequently found within a given soil type with respect to the presence of limestone and acidity, no attempt is made to include in the tabulated results figures purporting to represent the average amounts of these substances present in the respective types. Such averages cannot give the farmer the specific information he needs regarding the lime requirements of a given field. Fortunately, however, very simple tests which can be made at home will furnish this important information, and these tests are described on pages 28 and 29 of the Appendix.

The variation among the different types of soil of DeKalb county with respect to the content of important plant-food elements is very marked. For example, the deep peat contains, in the plowed soil of an acre, nearly twenty-two times as much nitrogen as does the yellow-gray sandy loam. Comparing the deep peat with the most common type in the county, we find about five times as much nitrogen in it as in the brown silt loam, while on the other hand the brown silt loam contains more than thirteen times as much potassium as is found in the deep peat. The supply of phosphorus in the surface soil varies from 760 pounds per acre in the yellow-gray sandy loam to 2,540 pounds in the black silt loam. A sulfur content of 240 pounds per acre is found in the yellow-gray sandy loam, while in the deep peat there are 7,110 pounds of this element. The magnesium varies in the different types from 2,560 to 39,780 pounds, and the calcium content ranges from 4,080 to 83,210 pounds per acre.

TABLE 2.—PLANT FOOD IN THE SOILS OF DEKALB COUNTY, ILLINOIS: SURFACE SOIL
Average pounds per acre in 2 million pounds of surface soil (about 0–6⅔ inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (700, 900, 1100)							
726, 926, 1126	Brown silt loam	69 440	5 940	1 340	990	32 960	8 140	11 460
725, 925, 1125	Black silt loam	107 360	10 580	2 540	1 700	26 180	11 960	20 900
1120	Black clay loam	102 540	9 500	2 440	1 400	35 600	15 200	22 100
760, 960, 1160	Brown sandy loam	34 540	3 000	1 080	660	28 340	4 780	6 840
790, 990, 1190	Gravelly loam	43 180	4 260	1 360	980	25 660	39 780	71 700
	(b) Upland Timber Soils (700, 900, 1100)							
734, 934, 1134	Yellow-gray silt loam	27 970	2 540	1 070	580	33 380	6 440	7 990
735, 935, 1135	Yellow silt loam	26 800	2 540	880	640	44 480	6 720	7 460
764, 964	Yellow-gray sandy loam	20 300	1 500	760	240	23 180	2 560	4 520
	(c) Terrace Soils (1500)							
1527	Brown silt loam over gravel	71 480	6 650	1 540	1 170	29 010	9 110	13 660
1525	Black silt loam	122 700	11 680	2 420	2 160	28 600	10 220	22 620
1536	Yellow-gray silt loam over gravel	34 360	2 900	1 100	580	35 160	6 320	8 300
1566	Brown sandy loam over gravel	25 460	2 140	960	540	24 680	3 240	4 080
	(d) Swamp and Bottom-Land Soils (1400)							
1450	Black mixed loam	149 150	14 000	2 510	2 040	22 090	19 570	83 210
1401	Deep peat[1]	380 320	32 810	1 900	7 110	2 380	5 520	44 480
1402	Medium peat on clay[1]	342 140	27 320	1 410	3 070	7 520	4 690	24 750
1454	Mixed loam	55 380	4 460	1 660	900	30 200	6 420	10 420

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures on limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in general averages adequate information concerning the limestone requirement. The limestone requirement for soils is extremely variable. It may vary from farm to farm, and even from field to field. Therefore no attempt is made to include in these tables figures purporting to represent for the various types the limestone content or the soil acidity present. The need for limestone should be determined on every farm and for each field individually. Fortunately this can be easily done by the simple tests described in the Appendix to this report, pages 28 and 29.

[1]Amounts reported are for 1 million pounds of deep peat and medium peat.

It is important to note that some of the plant-food elements are present in very limited quantities as compared with crop requirements. Some simple computations are of interest in this connection. Assume, for example, that a four-field crop rotation of wheat, corn, oats, and clover yields 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. These are high yields, but not impossible for they are sometimes obtained. It will be found that the most prevalent upland soil of DeKalb county, the brown silt loam, contains only enough total nitrogen in the plowed soil for the production of such yields to supply about twelve rotations.

TABLE 3.—PLANT FOOD IN THE SOILS OF DEKALB COUNTY, ILLINOIS: SUBSURFACE SOIL
Average pounds per acre in 4 million pounds of subsurface soil (about 6⅔–20 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (700, 900, 1100)							
726, 926, 1126	Brown silt loam	65 360	6 000	1 900	1 140	68 100	21 510	21 800
725, 925, 1125	Black silt loam	83 200	8 240	3 080	1 720	59 960	25 080	32 960
1120	Black clay loam	65 360	6 360	3 200	1 240	78 440	28 920	34 080
760, 960, 1160	Brown sandy loam	29 760	2 960	1 640	680	59 720	14 640	11 160
	(b) Upland Timber Soils (700, 900, 1100)							
734, 934, 1134	Yellow-gray silt loam	18 640	2 120	1 950	630	71 990	21 690	15 590
735, 935, 1135	Yellow silt loam	20 040	2 400	1 720	720	108 800	25 320	14 640
764, 964	Yellow-gray sandy loam	17 680	1 320	1 400	400	49 160	5 840	10 320
	(c) Terrace Soils (1500)							
1527	Brown silt loam over gravel	58 060	5 500	2 140	1 240	66 940	21 300	25 000
1525	Black silt loam	70 600	6 920	3 080	1 800	65 040	21 040	27 680
1536	Yellow-gray silt loam over gravel	28 400	2 920	2 120	760	71 800	19 520	17 880
1566	Brown sandy loam over gravel	16 480	1 480	1 360	600	53 040	9 680	9 520
	(d) Swamp and Bottom-Land Soils (1400)							
1450	Black mixed loam	113 840	10 580	3 580	1 860	53 220	51 220	106 660
1401	Deep peat[1]	825 040	65 320	3 880	19 880	8 360	12 300	72 980
1402	Medium peat on clay[1]	372 720	32 060	1 940	4 240	24 340	12 160	38 560
1454	Mixed loam	70 280	5 680	2 920	1 360	60 040	13 080	16 480

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]Amounts reported are for 2 million pounds of deep peat and medium peat.

With respect to phosphorus, the condition differs only in degree, this soil containing no more of that essential element than would be required for about eighteen crop rotations yielding at the rates suggested above. On the other hand the amount of potassium in the surface layer of this common soil type is sufficient for more than 25 centuries if only the grain is sold, or for nearly 400 years if the total crops should be removed from the land and nothing returned.

These general statements relating to the total quantities of these plant-food materials in the plowed soil of the most prevalent type in the county certainly emphasize the fact that the supplies of some of these necessary elements of fertility are extremely limited when measured by the needs of large crop yields for even one or two generations of people.

THE SUBSURFACE AND SUBSOIL

In Tables 3 and 4 are recorded the amounts of plant food in the subsurface and the subsoil of the different types. It should be remembered, however, that these supplies are of little value unless the top soil is kept rich. These tables also show great stores of potassium in the prevailing types of soil but only limited amounts of nitrogen and phosphorus, in agreement with the data for the corresponding surface samples.

TABLE 4.—PLANT FOOD IN THE SOILS OF DEKALB COUNTY, ILLINOIS: SUBSOIL
Average pounds per acre in 6 million pounds of subsoil (about 20–40 inches)

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (700, 900, 1100)							
726, 926, 1126	Brown silt loam	26 070	2 930	2 700	780	105 060	58 990	75 210
725, 925, 1125	Black silt loam	32 460	3 360	3 360	960	99 660	42 180	43 440
1120	Black clay loam	23 940	2 940	4 320	1 320	141 780	51 600	43 620
760, 960, 1160	Brown sandy loam	19 380	2 100	2 100	900	94 860	26 700	21 000
	(b) Upland Timber Soils (700, 900, 1100)							
734, 934, 1134	Yellow-gray silt loam	20 120	2 400	3 380	480	107 780	47 140	40 060
735, 935, 1135	Yellow silt loam	15 300	2 220	2 460	1 020	151 860	156 960	222 480
764, 964	Yellow-gray sandy loam	11 160	720	1 980	420	70 500	11 580	14 820
	(c) Terrace Soils (1500)							
1527	Brown silt loam over gravel	31 350	3 480	3 150	1 170	99 420	38 580	37 710
1525	Black silt loam	24 000	2 700	4 080	1 380	106 140	37 020	56 640
1536	Yellow-gray silt loam over gravel	21 660	2 520	3 900	720	96 000	39 900	33 600
1566	Brown sandy loam over gravel	16 020	1 380	1 680	660	81 480	13 560	17 100
	(d) Swamp and Bottom-Land Soils (1400)							
1450	Black mixed loam	88 980	7 620	5 700	1 890	84 360	102 810	187 710
1401	Deep peat[1]	801 900	57 420	5 220	24 690	27 600	22 620	83 610
1402	Medium peat on clay	285 060	20 520	3 120	6 660	112 200	49 500	64 440
1454	Mixed loam	41 400	3 660	3 900	1 320	96 780	26 160	28 200

LIMESTONE AND SOIL ACIDITY.—See note in Table 2.

[1]Amounts reported are for 3 million pounds of deep peat.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of DeKalb county cover 525.25 square miles, or more than four-fifths of the area of the county. They usually occupy the less rolling and comparatively level land, altho some exceptions to this are to be found. These prairie soils are dark in color owing to their relatively high organic-matter content. This land was originally covered with prairie grasses, the partially decayed roots of which have been the principal source of the organic matter. The flat, poorly drained areas contain the greatest amounts of organic matter, owing to the more luxuriant growth of grasses in such situations and to the excessive soil moisture which has provided conditions more favorable for their preservation.

Brown Silt Loam (726, 926, 1126)

Brown silt loam is the most extensive type in DeKalb county, covering 516.82 square miles, or more than 80 percent of the area of the county. It is found on the more level land, a considerable portion of which needs artificial drainage. While the type is primarily prairie, yet in some sections timber has extended over it to a slight extent. The trees found on the timbered areas are usually bur oak, wild cherry, and elm, but their occupation of the soil has not been sufficiently long to change its character to any great extent. The type, however, may include some small areas of yellow-gray silt loam (—34) too small to be shown on the map.

The surface soil, 0 to 6⅔ inches, is a brown silt loam varying from a yellowish brown on the more rolling areas to a dark brown or black on the more nearly level and poorly drained tracts. In physical composition it varies to some extent, but it normally contains from 50 to 75 percent of the different grades of silt. In the low areas the proportion of clay is usually higher than on the more rolling parts, where a perceptible amount of sand may occur. On account of of the varied topography of the type, the organic-matter content in the surface soil is rather variable, but it averages about 6 percent, or 60 tons per acre. In the more rolling phase, small patches are found which have been eroded to such an extent that the yellow subsoil appears. These areas are usually not large enough to be shown on the map as a separate type.

The natural subsurface is represented by a stratum varying from 5 to 16 inches in thickness. This variation is due to erosion, the stratum being thinner on the more rolling areas. In physical composition the subsurface varies about the same as the surface soil, but on the less rolling areas it normally contains a larger percentage of clay, while on the more rolling areas the sand content becomes greater. The organic-matter content varies with topography in the same manner as the surface, being greater on the more level land. It averages about 2.7 percent, or 54 tons per acre in a stratum 13⅓ inches thick. In color the subsurface varies from a dark brown or almost black to a light yellowish brown, which becomes lighter with increasing depth.

The natural subsoil begins 11 to 22 inches beneath the surface and extends to an indefinite depth. It varies from a yellow to a drabbish yellow, clayey material, sometimes composed wholly or in part of boulder clay or drift. The stratum sampled (20 to 40 inches) contains about .7 percent of organic matter. In some of the flat areas that are not subject to erosion, but where material has washed in from the higher surrounding land, the subsoil to a depth of 40 inches does not reach the boulder clay.

Each of the three strata is pervious to water, so that drainage takes place with little difficulty.

Management.—When the virgin brown silt loam was first cropped, the soil was in fine tilth, worked easily, and much less effort was required to produce a good seed bed than is now the case where the soil has been heavily cropped for many years and where the organic matter has not been maintained. Unless the moisture content is very favorable, the soil under this latter condition plows up cloddy, and the clods may remain all season. Much plant food will be locked up in them, and the best results cannot be obtained. The remedy for poor tilth is to increase the amount of organic matter by turning under every available form of vegetable matter, such as farm manure, corn stalks, straw, clover, stubble, and even weeds. The addition of fresh organic matter is not only of great value in improving the physical condition of this type of soil, but it is equally important because of its nitrogen content, and also because of its power, as it decays, to liberate potassium from the inexhaustible supply in the minerals of the soil and phosphorus from the phosphate contained in or applied to the soil. The deficiency of organic matter in the soil is shown by the way fall-plowed land runs together during the winter. In the spring, fall-plowed land should be disked early and deep for the purpose of conserving moisture, raising the temperature, and making plant food available.

For permanent, profitable systems of farming on brown silt loam, phosphorus should usually be applied liberally, and sufficient organic matter should be provided to furnish the necessary amount of nitrogen. While the subsoil usually contains an abundance of carbonates, on the prevailing phase of the type limestone is becoming deficient in the upper strata so that an application of 1 to 2 tons of limestone per acre is advisable, and in the preparation of the land for alfalfa heavier applications are justifiable. To enrich the soil in phosphorus, ½ to 1 ton of finely ground rock phosphate per acre should be applied about every four years. This treatment, along with the judicious return to the land of organic manures made from a good rotation, will not only maintain but will increase the fertility of this soil.

If grain farming is practiced, a good rotation to be suggested might be wheat, corn, oats, and clover, with an extra seeding of clover (preferably sweet clover) as a cover crop in the wheat, to be plowed under late in the fall or in the following spring for corn. Most of the crop residues, including the clover chaff from the seed crops, should also be plowed under. In live-stock farming, this rotation may be extended to five or six years by seeding both timothy and clover with the oats, and pasturing one or two years. In either the grain or the live-stock system, alfalfa may be grown on a fifth field and moved every rotation, the hay being fed or sold. Other suggestions for various crop rotation programs will be found in the Appendix (page 34).

For an account of field experiments on this type of soil the reader is referred to page 37 of the Supplement.

Black Silt Loam (725, 925, 1125)

Black silt loam is confined to small areas in depressions and along streams. It is generally scattered over the county and occurs in areas similar in location to those occupied by black clay loam in central Illinois. The type covers 5,094 acres, or 1.26 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a black, granular, silt to clayey silt loam. It contains normally about 9.2 percent of organic matter, or 92 tons per acre, altho in certain small areas the organic-matter content may vary from that of brown silt loam to that of muck.

The natural subsurface is represented by a stratum about 12 inches thick, and is a black silt loam passing into a drab clayey silt at 18 to 20 inches in depth. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 3.6 percent, or 72 tons per acre.

The subsoil is a drab or yellowish drab clayey silt or silty clay, sometimes containing pebbles. All strata are readily pervious to water.

Management.—The first consideration in the management of this type is drainage. The content of nitrogen and phosphorus is high, and no attention need be given these elements for some time if a good rotation is practiced. The limestone is often low, and applications may soon be necessary to produce the best results with legumes.

Alkali spots are common in this type. Applications of 150 to 200 pounds of potash salts per acre, or of several tons of coarse stable manure, or sweet clover turned under, will usually be effective in counteracting the effect of the alkali. These spots should be thoroughly tiled, as the leaching out of the alkali is about the only permanent remedy for removing it.

Black Clay Loam (1120)

The areas of black clay loam are about twelve in number and the largest does not cover more than 40 acres. The total area covered by this type is about 147 acres. A small area occurring on the terrace is included with this upland type.

The surface soil, 0 to 6⅔ inches, is a black, plastic, granular clay loam containing about 8.8 percent of organic matter, or 88 tons per acre.

The subsurface is a black clay loam with about 2.8 percent of organic matter, or 56 tons per acre.

The subsoil is a drab to yellowish drab silty clay or clayey silt.

Management.—Drainage is the first requirement of this type. It is abundantly supplied with plant food, but is somewhat acid and may need limestone for legumes, altho there are areas where alkali is so abundant as to be injurious. The treatment for alkali is the same as that described for the alkali spots in the preceding type.

Brown Sandy Loam (760, 960, 1160)

Brown sandy loam occurs in a few small isolated areas covering in total about 77 acres. It has been formed by sand blown from the bottom land onto the adjoining upland.

The surface soil, 0 to 6⅔ inches, is a brown sandy loam containing about 3 percent of organic matter, or 30 tons per acre.

The natural subsurface, consisting of a stratum about 9 inches thick, is a brown sandy loam. The stratum as sampled (6⅔ to 20 inches), contains about 1.3 percent of organic matter.

The subsoil is a sandy silt or a silty sand of a yellow color.

Management.—The type is fairly well supplied with phosphorus and at present the most important consideration is the maintenance of the organic-matter and nitrogen contents. The recommendation, therefore, is the same as that suggested for brown silt loam.

Gravelly Loam (790, 990, 1190)

Gravelly loam occurs in several small spots in various parts of the county and covers as a total about 77 acres. An eskerlike gravel ridge about one mile in length, in Sections 5 and 6, Township 38 North, Range 5 East, is the largest area. The type is variable and of little agricultural value.

(b) UPLAND TIMBER SOILS

The upland timber soils usually occur along streams, altho two exceptions are found in DeKalb county where forests exist remote from streams. Timber soils are characterized by a yellow, yellowish gray, or gray color, due to their low organic-matter content resulting from the long-continued growth of forest trees. As the forests invaded the prairies, two effects were produced: (1) the shade from the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large amount of organic matter in prairie soils; (2) the trees themselves added very little organic matter to the soil, for the leaves and fallen branches either decayed completely or were burned by forest fires. As a result the timber soils contain a relatively low percentage of organic matter.

The total area of upland timber soils in DeKalb county is 41.99 square miles.

Yellow-Gray Silt Loam (734, 934, 1134)

Yellow-gray silt loam occurs in the outer timber belts along streams, and in the less rolling of the timbered morainal areas. The type covers 41.46 square miles, or 6.55 percent of the entire area of DeKalb county. In topography, it is sufficiently rolling for good surface drainage, without much tendency to wash if proper care is taken. The effect of the prevailing southwesterly winds may be seen in the distribution of the type. It is nearly all on the north and east side of the Kishwaukee river. The wind, as well as prairie fires, controlled such distribution.

The surface soil, 0 to 6⅔ inches, is a yellow, yellowish gray, gray, or brownish gray silt loam, having a floury feel. The more nearly level areas incline toward a grayish color, while the more rolling phase of the type has a yellow or brownish yellow color. As the type approaches the brown silt loam (—26), the organic matter increases until it grades into that type. The organic-matter content averages 2.4 percent, or 24 tons per acre, and is somewhat lower in the Iowan glaciation than in the early Wisconsin.

The natural subsurface soil is represented by a stratum from 3 to 10 inches thick. It is usually a gray, grayish yellow, or yellow silt loam, somewhat pulverulent, but becoming more coherent and plastic with increasing depth. The subsurface as sampled (6⅔ to 20 inches) contains about .8 percent of organic matter, or 16 tons per acre in four million pounds of soil.

The subsoil is a yellow or mottled grayish yellow, clayey silt or silty clay, somewhat plastic when wet, but friable when only moist, and pervious to water.

Owing to the removal by erosion of part of the loessial material, glacial drift is sometimes encountered at a depth of less than 40 inches. The glacial drift may be locally a very gravelly deposit, but usually it is a slightly gravelly clay.

Management.—In the management of this yellow-gray silt loam, one of the most essential points is the maintaining or the increasing of organic matter. This is necessary in order to supply nitrogen, to liberate mineral plant food, to give better tilth, to prevent ''running together,'' and, on some of the more rolling phases, to prevent washing.

Another essential is that the acidity of the soil be neutralized by the application of ground limestone, so that clover, alfalfa, and other legumes may be grown more successfully. The initial application may well be 2 to 4 tons per acre, after which a sufficient amount may be applied to keep the soil in good condition for growing legumes. Since the soil is poor in phosphorus, this element should be supplied, preferably in connection with farm manure or clover plowed under. In permanent systems of farming, finely ground natural rock phosphate will be found the most economical form in which to supply the phosphorus.

Among the crops deserving of special consideration for this type of soil are sweet clover and alfalfa. On soil deficient in organic matter sweet clover grows better than almost any other legume, and the fact that it is a very deep-rooting plant makes it of value for opening up the subsoil, increasing the organic matter, and preventing washing. Slopes that have been made worthless by washing may be made profitable as pasture by growing sweet clover. The blue grass of pastures may well be supplemented by sweet clover and alfalfa, and a larger growth obtained, because the legumes provide the necessary nitrogen for the blue grass.

To get alfalfa well started requires the liberal use of limestone, thoro inoculation with nitrogen-fixing bacteria, and a moderate application of farm manure. If manure is not available, it is well to apply about 500 pounds per acre of acid phosphate or steamed bone meal, mix it with the soil, by disking if possible, and then plow it under. The limestone (about 4 or 5 tons per acre) should be applied after plowing and should be mixed with the surface soil in the preparation of the seed bed. The special purpose of this treatment is to insure for the alfalfa a vigorous early growth.

See page 50 of the Supplement for an account of field experiments on this type of soil.

Yellow Silt Loam (735, 935, 1135)

Yellow silt loam covers only 275 acres in DeKalb county. It occurs as hilly and badly eroded land on the inner timber belts adjacent to the stream valleys, usually only in narrow, irregular strips. In topography it is very rolling, and in most places so badly broken that it should not be cultivated because of the danger of injury from washing.

The surface soil, 0 to 6⅔ inches, is a yellow or grayish yellow, pulverulent silt loam. It varies greatly in color and texture, owing to recent washing. In places the natural subsoil may be exposed. This exposure gives the surface a decidedly yellow color. When freshly plowed the soil appears yellow or brownish yellow, but when it becomes dry after a rain, it is of a grayish color. In some places the surface soil is formed from glacial drift, but this is only on very limited areas and on the steepest slopes. The organic-matter content averages 2.3 percent, or 23 tons per acre.

The natural subsurface varies from a yellow silt loam to a yellow clayey silt loam, and on the slopes that have been subjected to recent erosion, may consist of glacial drift. The stratum as sampled (6⅔ to 20 inches) contains about .8 percent of organic matter, or 16 tons per acre.

The natural subsoil is composed almost entirely of yellow boulder clay. Where recent erosion has taken place, all strata may be boulder clay.

Management.—One of the best uses to which this type can be put is permanent pasture. As a rule it cannot be satisfactorily cropped in ordinary rotations because it is so hilly, but it may be used very successfully for long rotations with pasture or meadow much of the time. Where both the surface and subsurface are acid, ground limestone may well be used for legumes in the rotation or even as a top dressing to encourage their growth in pastures. Where this type has been long cultivated and thus exposed to surface washing, it is particularly deficient in nitrogen. Among the crops that are perhaps best adapted to this type sweet clover and alfalfa should be mentioned. Suggestions concerning their culture have already been given in connection with the discussion of yellow-gray silt loam (page 15).

Yellow-Gray Sandy Loam (764, 964, 1164)

Yellow-gray sandy loam occurs principally in the northern part of the county as a few small areas, which make a total of 64 acres.

The surface soil, 0 to 6⅔ inches, is a yellow or grayish yellow sandy loam usually containing some gravel; in a few instances small patches of gravelly loam occur. The soil is made largely from sandy till. The organic-matter content is about 1.8 percent, or 18 tons per acre.

The natural subsurface stratum varies from 3 to 10 inches in thickness. It is of a lighter color than the surface soil owing to the smaller amount of organic matter present. This stratum is usually formed from gravelly, sandy till, but it often contains a considerable proportion of clay.

The subsoil varies from gravelly till to sand.

Management.—For the improvement of this type, the addition of organic matter and nitrogen is essential. Limestone should also be applied liberally for the best results with legumes. Where the subsurface and subsoil are very compact, owing to the presence of silt and clay, sweet clover should be grown to loosen the subsoil.

(c) TERRACE SOILS

The terrace soils in DeKalb county usually occur along streams. They were formed at a time when the streams, owing to melting glacier ice, were much larger than they are at present, and carried large amounts of coarse material such as sand and gravel. Upon any decrease in their velocity, these overloaded streams would deposit debris along their courses; and this resulted in the partial filling of the valley and the forming of what are now the terraces, bench lands, or second bottom lands. Finer material later deposited over this sand and gravel forms the present soil.

When the streams again reached their normal size after the glacier had melted, they began cutting down thru the deposit, and they are now so low that the terraces, or benches, do not overflow. A gravel outwash plain occurs in the northeastern part of Township 42 North, Range 5 East, that was formed when the shallow water of the melting ice spread over a large level area and deposited sand and gravel which was later covered with a fine material well adapted to forming a good soil.

Brown Silt Loam over Gravel (1527)

Brown silt loam over gravel is found principally in the northern half of the county along the South Branch of the Kishwaukee river, occurring almost entirely on the south and west sides of this stream. Another area is found in the northeast part of the county along the county line. This is a gravel outwash plain. Doubtless at one time some of the water of Coon creek valley flowed west across Sections 15 and 22, Township 42 North, Range 5 East, into the South Branch of the Kishwaukee. The type covers an area of 9,837 acres, or nearly 2.5 percent of the county. The depth to gravel varies from 30 to more than 50 inches, the average being a little more than 40 inches.

The surface soil, 0 to 6⅔ inches, is a brown silt loam varying to black. In physical composition it varies from a clayey silt loam to a loam or even to a sandy loam in areas too small to be shown on the map. It usually contains a perceptible amount of sand. The topography is generally flat, but slight undulations may occur that were probably produced by the channels of the flooded streams. The surface stratum contains approximately 6.2 percent of organic matter, or 62 tons per acre, the amount varying from 47 to 77 tons per acre.

The natural subsurface varies from 7 to 16 inches in thickness. The stratum sampled (6⅔ to 20 inches) contains about 2.5 percent of organic matter, or 50 tons per acre. In physical composition it is about the same as the surface soil.

The subsoil is a yellow to drabbish mottled yellow silt loam, with some gravel appearing in the deeper subsoil.

All strata are pervious to water, so that drainage is practically perfect where the water table is sufficiently low. The gravel is so far from the surface that crops do well even in years of some drouth. This is one of the best of the terrace types.

Management.—In the improvement of this type limestone, phosphorus, and organic matter should be provided in about the same amounts as those recommended for the brown silt loam of the prairie (—26). However, because of the greater porosity of this type, applications of phosphorus are likely to occupy third place in immediate effect.

Black Silt Loam (1525)

Black silt loam occurs only in the northern part of the county in Township 42 North along the Kishwaukee, and covers 979 acres. The topography is flat.

The surface soil, 0 to 6⅔ inches, is a black granular silt loam, locally becoming a clayey silt loam. This stratum contains about 10.6 percent of organic matter, or 106 tons per acre.

The natural subsurface soil is from 10 to 14 inches in thickness. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 3 percent.

The subsoil is a pale yellow to a drabbish yellow silt or clayey silt. It contains about .7 percent of organic matter.

Management.—The strata are pervious to water and drainage takes place readily by means of tile. Aside from drainage, good cultivation is about the only requirement at present, since the plant-food elements are usually abundant. Some alkali areas occur which may be greatly improved by turning under sweet clover.

Yellow-Gray Silt Loam over Gravel (1536)

With the exception of two small areas near Sandwich, yellow-gray silt loam over gravel is found in the northern half of the county, chiefly along the east and north sides of the Kishwaukee river. The type covers altogether 3,187 acres.

The surface soil, 0 to 6⅔ inches, is a grayish or yellowish gray silt loam, containing about 3 percent of organic matter, or 30 tons per acre. It varies in physical composition from a silt loam to a loam, and in small areas it may approach even a sandy loam.

The natural subsurface, comprizing a stratum from 6 to 10 inches thick, is a yellow to grayish yellow silt loam. The stratum sampled (6⅔ to 20 inches) contains about 1.3 percent of organic matter.

The subsoil is a clayey silt of a yellow or slightly grayish yellow color. Gravel occurs at a depth of 38 to 48 inches.

Management.—The low content of organic matter and nitrogen calls for the liberal use of leguminous crops, but to make conditions most favorable for their growth limestone should be applied at the rate of about 2 tons per acre. Phosphorus is likewise low and this element should be replenished by the use of rock phosphate.

Brown Sandy Loam over Gravel (1566)

Brown sandy loam over gravel occurs in a few small areas in the northeastern part of the county, and covers a total of 90 acres. The gravel lies from 40 to 50 inches below the surface.

The surface soil, 0 to 6⅔ inches, is a rather light colored brown sandy loam containing about 2.2 percent of organic matter, or 22 tons per acre.

The natural subsurface soil is represented by a stratum 4 to 9 inches thick. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about .7 percent.

The subsoil is a yellow sand to silty sand. Gravel occurs at 40 to 50 inches.

Management.—This type should be managed the same as the brown sandy loam of the upland (see page 14).

(d) SWAMP AND BOTTOM-LAND SOILS

In the group designated as swamp and bottom-land soils are included the overflow land or flood plains along streams, the swamps, and the poorly drained lowlands. The four types recognized as belonging to this group make up nearly 7 percent of the area of DeKalb county.

Black Mixed Loam (1450)

Black mixed loam occurs in a large number of small, isolated areas all over the county. These occur principally in low places that were formerly swamps, ponds, or sloughs. The largest areas of this type are found in the northeast part of the county. The total area of this soil is 22.24 square miles, or 14,233 acres.

The surface soil, 0 to 6⅔ inches, varies widely in its physical composition. For example, on a single ten acres, borings of shallow peat, black sandy loam, peaty loam, and gravelly loam were found. The samples taken to represent the type contained approximately 12.9 percent of organic matter.

The natural subsurface varies in thickness from 8 to 24 inches. In physical composition, it varies in somewhat the same manner as the surface, except that it is generally lighter in color. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 9.8 percent.

The subsoil is more uniform than the other strata and is usually a gray, drab, or yellow silty or clayey material.

Management.—Drainage is the first requirement and since all strata are pervious, drainage is a comparatively easy matter if a sufficient outlet can be obtained. All varieties of the type are very rich in nitrogen and elements of plant food generally, with possibly the exception of potassium in the more peaty phase of the type.

Deep Peat (1401)

Deep peat is well distributed over the county, but usually occurs only in small areas. The total area of the type is 1,293 acres.

The surface soil, 0 to 6⅔ inches, is a brown to black peat, containing about 65.6 percent of organic matter, or 328 tons per acre.

The subsurface stratum is about 13 inches thick and is similar to the surface except that it contains more organic matter, about 71.1 percent.

The subsoil contains, in the area sampled, about 46 percent of organic matter.

Management.—Drainage is of first importance with this type, but in many cases is very difficult to secure. Tile cannot be laid to the best advantage in peat on account of irregular settling and the consequent displacement of the line. This difficulty may be partly overcome by placing the tiles upon boards laid in the bottom of the ditch.

Where thoro drainage can be provided, either by the above method, by open ditches, or by laying tiles deep enough to secure a solid bed for them, very marked improvement can be made in the productive power of deep peat by the liberal use of potassium, which is by far the most deficient element. The type is well supplied with phosphorus.

For an account of field experiments on deep peat the reader is referred to page 53 of the Supplement.

Medium Peat on Clay (1402)

Medium peat on clay is found in only a few small areas in the northern half of the county and covers an area of but 26 acres.

The surface soil, 0 to 6⅔ inches, is a brown to black peat with about 59 percent of organic matter.

The subsurface contains about 32 percent of organic matter.

The clay subsoil contains about 8.2 percent of organic matter.

Management.—If this type is not productive when well drained, it may, in some cases where the clay is not too deep, be improved by extra deep plowing. By this process clayey material, with its higher potassium content, is incorporated with the peat. When this cannot be done, the use of coarse manure or of commercial potassium is advised.

Mixed Loam (1454)

Mixed loam occurs as irregular bottoms along the streams, practically all of which overflow. The total area covered is 12,224 acres, or about 3 percent of the area of the county.

The surface soil, 0 to 6⅔ inches, is a mixed loam varying from a black silty clay loam to a brown sandy loam. Occasionally small patches of peat are found. The sample taken contained about 4.8 percent of organic matter, or 48 tons per acre.

The subsurface is a brown mixed loam varying in physical composition the same as the surface. It contains, according to the sample, about 3 percent of organic matter.

The subsoil is a brownish silt to sandy loam, becoming lighter with increasing depth.

Management.—In the management of this type, good cultivation is about the only thing to be considered.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to intelligently interpret the soil maps, the reader must understand something of the method of soil classification upon which the survey is based. Without going far into details the following paragraphs are intended to furnish a brief explanation of the general plan of classification here used.

The unit in the soil survey is the soil type, and each type possesses more or less definite characteristics. The line of separation between adjoining types is usually distinct, altho sometimes one type grades into another so gradually that it is very difficult to draw the line between them. In such exceptional cases, some slight variation in the location of soil-type boundaries is unavoidable.

In establishing soil types several factors must be taken into account. These are: (1) the geological origin of the soil, whether residual, cumulose, glacial, eolial, alluvial, or colluvial; (2) the topography, or lay of the land; (3) the native vegetation, as prairie grasses or forest; (4) the depth and the character of the surface, the subsurface, and the subsoil, as to the percentages of gravel, sand, silt, clay, and organic matter which they contain, their porosity, granulation, friability, plasticity, color, etc.; (5) the natural drainage; (6) the agricultural value, based upon its natural productiveness; (7) the ultimate chemical composition and reaction.

Great Soil Areas in Illinois.—On the basis of the first of the above mentioned factors, namely, the geological origin, the state of Illinois has been divided into seventeen great soil areas with respect to their geological formation. The names of these areas are given in the following list along with their corresponding index numbers, the use of which is explained below. For the location of these geological areas, the reader is referred to the general map published in Bulletins 123 and 193.

000 *Residual,* soils formed in place thru disintegration of rocks, and also rock outcrop
100 *Unglaciated,* comprizing three areas, the largest being in the south end of the state
200 *Illinoisan moraines,* including the moraines of the Illinoisan glaciations
300 *Lower Illinoisan glaciation,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

Mechanical Composition of Soils.—The mechanical composition, or the texture, is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents:

Organic matter: undecomposed and partially decayed vegetable material
Inorganic matter: clay, silt, fine sand, sand, gravel, stones

Classes of Soils.—Based upon the relative proportion of the various constituents mentioned above, soils may be grouped into a number of well recognized classes. Following is a list of these classes, arranged according to their index numbers, the use of which is explained below:

Index Number Limits	Class Names
0 to 9	Peats
10 to 12	Peaty loams
13 to 14	Mucks
15 to 19	Clays
20 to 24	Clay loams
25 to 49	Silt loams
50 to 59	Loams
60 to 79	Sandy loams
80 to 89	Sands
90 to 94	Gravelly loams
95 to 97	Gravels
98	Stony loams
99	Rock outcrop

Naming and Numbering Soil Types.—The naming of soil types has been the subject of much discussion, and practice varies considerably in this matter. In this soil survey of Illinois a system of classification and naming has been adopted which is based upon the various considerations presented in the preceding paragraphs.

After texture, one of the most striking characteristics of a soil is the color. Therefore, in the naming of soils in Illinois, a combination of color and texture, together with other descriptive terms when necessary, has been adopted so that the name in itself carries a definite description of a given soil type; as for example, "gray silt loam on tight clay," or "brown silt loam over gravel." The use of the prepositions *on* and *over* serves to indicate the presence of certain substrata. When the surface soil is underlain with material such as sand, gravel, or rock, the word *over* is used if this material lies at a depth greater than 30 inches; if it is less than 30 inches, the word *on* is used.

For further identification of soil types a system of numbering, resembling somewhat the Dewey library system, has been adopted whereby each soil type is assigned a certain number. This number indicates at once the geological origin of the soil as well as its physical description. The digits of the order of hundreds represent the geological area where the soil is found, beginning with 000, the residual, followed by 100, the unglaciated, and the rest of the series in the order of the enumeration presented in the paragraph above headed *Great Soil Areas in Illinois*. The digits of the orders of units and tens represent the various kinds of soil such as are enumerated above in the list of soil classes. Certain modifications are designated in this system by a figure placed at the right of the decimal point. To illustrate the working of this numbering system, suppose a soil type bears the number 726.5. The number 7 indicates that this soil occurs in the Iowan glaciation, the 26 that it is a brown silt loam, and the .5 that rock is found less than 30 inches below the surface. These numbers are especially useful in designating small areas on the map and as a check in reading the colors.

A complete list of the soil types occurring in each county, along with their corresponding type numbers and the area covered by each type, will be found in the respective county soil reports.

SOIL SURVEY METHODS

Mapping the Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. In order that the survey be thoroly trustworthy it is necessary that careful, well-trained men be employed to do the mapping. The work is prosecuted to the best advantage by working in parties of from two to four. Only such men are placed in charge of these parties as are thoroly experienced in the work and have shown themselves to be especially well qualified in training and ability.

The men must be able to keep their location exactly and to recognize the different soil types, with their principal variations and limits, and they must show these upon the maps correctly. A definite system is employed in checking up this work. As an illustration, one man will survey and map a strip 80 rods or 160 rods wide and any convenient length, while his associate will work independently on another strip adjoining this area, and if the work is correctly done the soil-type boundaries will match up on the line between the two strips.

An accurate base map for field use is absolutely necessary for soil mapping. The base maps are prepared on a scale of one inch to the mile, the official data of the original or subsequent land survey being used as a basis in their construction. Each surveyor is provided with one of these base maps, which he carries with him in the field; and the soil-type boundaries, together with the streams, roads, railroads, canals, and town sites are placed in their proper locations upon the map while the mapper is on the area. Each section, or square mile, is divided into 40-acre plots on the map, and the surveyor must inspect every ten acres and determine the type or types of soil thereon. The different types are indicated on the map by different colors, pencils for this purpose being carried in the field.

A small auger 40 inches long forms for each man an invaluable tool with which he can quickly secure samples of the different strata for inspection. An extension for making the auger 80 inches long is taken by each party, so that any peculiarity of the deeper subsoil layers may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or by some other measuring device, while distances in the field away from the roads are determined by pacing, an art in which the men become expert by practice. The soil boundaries can thus be located with as high a degree of accuracy as can be indicated by pencil on the scale of one inch to the mile.

Sampling for Analysis.—After all the soil types of a county have been located and mapped, samples representative of the different types are collected for chemical analysis. For this purpose usually three strata are sampled; namely, the surface (0 to 6⅔ inches), the subsurface (6⅔ to 20 inches), and the subsoil

(20 to 40 inches). These strata correspond approximately, in the common kinds of soil, to 2,000,000 pounds of dry soil per acre in the surface layer, and to two times and three times this quantity in the subsurface and the subsoil, respectively. This is, of course, a purely arbitrary division, very useful in arriving at a knowledge of the quantity and the distribution of plant food in the soil, but it should be noted that these strata do not necessarily coincide with the natural strata as they actually exist in the soil, and which are referred to in describing the soil types.

By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow. This is the part with which the farm manure, limestone, phosphate, or other fertilizer applied in soil improvement is incorporated, and which must be depended upon in large part to furnish the necessary plant food for the production of crops. A rich subsoil has little or no value if it lies beneath a worn-out surface, but if the fertility of the surface soil is maintained at a high point, then the strong vigorous plants will have power to secure more plant food from the subsurface and subsoil.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. Even tho plowed alike and at the same time, prepared the same way, planted the same day with the same kind of seed, and cultivated alike, watered by the same rains and warmed by the same sun, nevertheless the best acre may produce twice as large a crop as the poorest acre on the same farm, if not, indeed, in the same field; and the fact should be repeated and emphasized that with the normal rainfall of Illinois the productive power of the land depends primarily upon the stock of plant food contained in the soil and upon the rate at which it is liberated, just as the success of the merchant depends primarily upon his stock of goods and the rapidity of sales. In both cases the stock of any commodity must be increased or renewed whenever the supply of such commodity becomes so depleted as to limit the success of the business, whether on the farm or in the store.

CROP REQUIREMENTS

Ten different elements of plant food are essential for the growth and formation of every plant. These elements are: *carbon, oxygen, hydrogen, nitrogen, phosphorus, sulfur, potassium, magnesium, calcium, and iron;* and they are represented by the chemical symbols: C, O, H, N, P, S, K, Mg, Ca, and Fe. Some seasons in central Illinois are sufficiently favorable to allow the production of at least 50 bushels of wheat per acre, 100 bushels of corn, 100 bushels of oats, and 4 tons of clover hay. When such crops, growing under favorable climatic and cultural conditions and uninjured by disease or insect pests, are not produced the failure is due to unfavorable soil condition, which may result from poor drainage, poor physical condition, or from an actual deficiency of plant food.

Table A shows the plant-food requirements of some of our most common field crops with respect to the seven elements furnished by the soil. The figures show the weight in pounds of the various elements contained in a bushel or in a

TABLE A.—PLANT FOOD IN WHEAT, CORN, OATS AND CLOVER

Produce		Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
Kind	Amount							
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Wheat, grain	1 bu.	1.42	.24	.10	.26	.08	.02	.01
Wheat, straw	1 ton	10.00	1.60	2.70	18.00	1.60	3.80	.60
Corn, grain	1 bu.	1.00	.17	.08	.19	.07	.01	.01
Corn stover	1 ton	16.00	2.00	2.42	17.33	3.33	7.00	1.60
Corn cobs	1 ton	4.00	.....	.....	4.00	.....	.....	.....
Oats, grain	1 bu.	.66	.11	.06	.16	.04	.02	.01
Oat straw	1 ton	12.40	2.00	4.14	20.80	2.80	6.00	1.12
Clover seed	1 bu.	1.75	.50	.....	.75	.25	.13	.....
Clover hay	1 ton	40.00	5.00	3.28	30.00	7.75	29.25	1.00

ton, as the case may be. From these data the amount of any element removed from an acre of land by a crop of a given yield can easily be computed.

It needs no argument to show that the continuous removal of such quantities of plant food without provision for their replacement must result sooner or later in soil depletion.

PLANT-FOOD SUPPLY

Of the ten elements of plant food, three (*carbon, oxygen,* and *hydrogen*) are secured from air and water, and seven from the soil. *Nitrogen,* one of these seven elements obtained from the soil by all plants, may also be secured from the

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	19
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[1]	80	8	28
Dried blood	280	...	...
Sodium nitrate	310	...	...
Ammonium sulfate	400	...	...
Raw bone meal	80	180	...
Steamed bone meal	20	250	...
Raw rock phosphate	...	250	...
Acid phosphate	...	125	...
Potassium chlorid	...	...	850
Potassium sulfate	...	...	850
Kainit	...	...	200
Wood ashes[2]	...	10	100

[1]Young second year's growth ready to plow under as green manure.
[2]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

air by one class of plants (legumes), in case the amount liberated from the soil is insufficient; but even these plants (which include only the clovers, peas, beans, and vetches among our common agricultural plants) are dependent upon the soil for the other six elements (*phosphorus, potassium, magnesium, calcium, iron,* and *sulfur*), and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to nearly 33,000 pounds. In like manner the phosphorus content varies from about 420 to 4,900 pounds, the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table B is presented for the purpose of furnishing information regarding the quantity of plant food contained in some of the materials most commonly used as sources of plant-food supply.

LIBERATION OF PLANT FOOD

The chemical analysis of the soil gives the invoice of fertility actually present in the soil strata sampled and analyzed, but the rate of liberation is governed by many factors, some of which may be controlled by the farmer, while others are largely beyond his control. Chief among the important controllable factors which influence the liberation of plant food are the choice of crops to be grown, the use of limestone, and the incorporation of organic matter. Tillage, especially plowing, also has a considerable effect in this connection.

Feeding Power of Plants.—Different species of plants exhibit a very great diversity in their ability to obtain plant food directly from the insoluble minerals of the soil. As a class, the legumes—especially such biennial and perennial legumes as red clover, sweet clover, and alfalfa—are endowed with unusual power to assimilate from mineral sources such plant foods as calcium and phosphorus, converting them into available forms of food for the crops that follow. For this reason it is especially advantageous to employ such legumes in connection with the application of limestone and rock phosphate. Thru their growth and subsequent decay large quantities of the mineral foods are liberated for the benefit of the less independent feeding cereal crops which follow in the rotation. Moreover, as an effect of the deep rooting habit of these legumes, large quantities of mineral plant foods are brought up and rendered available from the vast reservoirs of the lower subsoil.

Effect of Limestone.—Limestone corrects the acidity of the soil and thus encourages the development not only of the nitrogen-gathering bacteria which live in the nodules on the roots of clover, cowpeas, and other legumes, but also the nitrifying bacteria, which have power to transform the insoluble and unavailable organic nitrogen into soluble and available nitrate nitrogen. At the same time, the products of this decomposition have power to dissolve the minerals contained in the soil, such as potassium and magnesium, and also to dissolve the insoluble phosphate and limestone which may be applied in low-priced forms. Thus, in the conversion of sufficient organic nitrogen into nitrate nitrogen for a 100-bushel crop of corn, the nitrous acid formed is alone sufficient to convert seven times as much insoluble tricalcium phosphate into soluble monocalcium phosphate as would be required to supply the phosphorus for the same crop.

Organic Matter and Biological Action.—Organic matter may be supplied by animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant food than the 20 tons of old, inactive organic matter. The history of the individual farm or field must be depended upon for information concerning recent additions of active organic matter, whether in applications of farm manure, in legume crops, or in sods of old pastures.

The condition of the organic matter of the soil is indicated to some extent by the *ratio of carbon to nitrogen*. Fresh organic matter recently incorporated with the soil contains a very much higher proportion of carbon to nitrogen than do the old resistant organic residues of the soil. The proportion of carbon to nitrogen is higher in the surface soil than in the corresponding subsoil, and in general this ratio is wider in highly productive soils well charged with active organic matter than in very old, worn soils badly in need of active organic matter.

The organic matter furnishes food for bacteria, and as it decays certain decomposition products are formed, including much carbonic acid, some nitrous acid, and various organic acids, and these acting upon the soil have the power to dissolve the essential mineral plant foods, thus furnishing soluble phosphates, nitrates, and other salts of potassium, magnesium, calcium, etc., for the use of the growing crop.

Effect of Tillage.—Tillage, or cultivation, also hastens the liberation of plant food by permitting the air to enter the soil. It should be remembered, however, that tillage is wholly destructive, in that it adds nothing whatever to the soil, but always leaves it poorer, so far as plant food is concerned. Tillage should be practiced so far as is necessary to prepare a suitable seed bed for root development and also for the purpose of killing weeds, but more than this is unnecessary and unprofitable; and it is much better actually to enrich the soil by proper applications of limestone, organic matter and other fertilizing materials, and thus promote soil conditions favorable for vigorous plant growth, than to depend upon excessive cultivation to accomplish the same object at the expense of the soil.

PERMANENT SOIL IMPROVEMENT

According to the kind of soil involved, any comprehensive plan contemplating a permanent system of agriculture will need to take into account some of the following considerations.

The Application of Limestone

The Function of Limestone.—In considering the application of limestone to land it should be understood that this material functions in several different ways, and that a beneficial result may therefore be attributable to quite diverse causes. Limestone provides the plant food calcium, of which certain crops are strong feeders. It corrects acidity of the soil, thus making for some crops a much more favorable environment as well as establishing conditions absolutely required for some of the beneficial legume bacteria. It accelerates nitrification and nitrogen fixation. It promotes sanitation of the soil by preventing the growth of certain fungus diseases, such as corn root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement.

Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands. Remarkable success has been experienced with limestone used in conjunction with sweet clover in the reclamation of abandoned hill land which had been ruined thru erosion.

Amounts to Apply.—If the soil is acid, usually at least 2 tons per acre of ground limestone should be applied as an initial treatment. Continue to apply limestone from time to time according to the requirement of the soil as indicated by the tests described below, or until the most favorable conditions are established for the growth of legumes, using preferably at times magnesian limestone ($CaCO_3MgCO_3$), which contains both calcium and magnesium and has slightly greater power to correct soil acidity, ton for ton, than the ordinary calcium limestone ($CaCO_3$). On strongly acid soils, or on land being prepared for alfalfa, 4 or 5 tons per acre of ground limestone may well be used for the first application.

How to Ascertain the Need for Limestone.—The need of a soil for limestone may be ascertained by applying one of the following tests for soil acidity. Along with the acidity test, a test for the presence of carbonates should be made. It should be understood that a positive test for carbonates does not guarantee the absence of acid; for it may happen, especially when the soil is near the neutral point, that positive tests for both acidity and carbonates are obtained. This condition is explained by the assumption that solid particles of calcium or magnesium carbonates form centers of alkalinity within a soil that is generally acid. Because of this fact any test made of a given soil ought to be repeated if it is to be thoroly reliable. It is also desirable to test samples from different depths. Following are the directions for making these tests:

The Litmus Paper Test for Acidity. Make a ball of fresh moist soil, break it in two, insert a piece of blue litmus paper, and press the soil firmly together. After a few minutes examine the paper. If it has turned pink or red, soil acidity is indicated. The intensity of the color and the rapidity with which it develops indicates to some extent the amount of acidity. Needless to say the reliability of the test depends upon the quality of litmus paper used.

The Potassium Thiocyanate Test for Acidity. A more recently discovered test for soil acidity which promises to be more satisfactory than the litmus test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. The conditions for a prompt reaction require a temperature that is comfortably warm.

The Hydrochloric Acid Test for Carbonates. Make a shallow cup of a ball of soil and pour into it a few drops of concentrated hydrochloric acid. If carbonates are present they are decomposed with the liberation of carbon dioxid, which appears as gas bubbles, producing foaming or effervescence. With much carbonate present the action is lively, but with mere traces of it the bubbles are given off slowly. If no carbonate, or very little, is indicated by the test, then it is advisable to apply limestone.

The Nitrogen Problem

Nitrogen presents the greatest practical soil problem in American agriculture. Four important reasons for this are: its increasing deficiency in most soils; its cost when purchased on the open market; its removal in large amounts by crops; and its loss from soils thru leaching. Nitrogen costs from four to five times as much per pound as phosphorus. A 100-bushel crop of corn requires 150 pounds of nitrogen for its growth, but only 23 pounds of phosphorus. The loss of nitrogen from soils may vary from a few pounds to over one hundred pounds per acre, depending upon the treatment of the soil, the distribution of rainfall, and the protection afforded by growing crops.

An inexhaustible supply of nitrogen is present in the air. Above each acre of the earth's surface there are about sixty-nine million pounds of atmospheric nitrogen. The nitrogen above one square mile weighs twenty million tons, an amount sufficient to supply the entire world for four or five decades. This large supply of nitrogen in the air is the one to which the world must eventually turn.

There are two methods of collecting the inert nitrogen gas of the air and combining it into compounds that will furnish products for agricultural uses. *These are the chemical and the biological fixation of the atmospheric nitrogen.* Farmers have at their command one of these methods. By growing inoculated legumes, nitrogen may be obtained from the air, and by plowing under more than the roots of those legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for feed and seed as well as for nitrate production, a considerable portion of the nitrogen thus gained may be considered a by-product. Because of that fact, it is questionable whether the chemical fixation of nitrogen, the possibilities of which now represent numerous compounds, will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes.

For easy figuring it may well be kept in mind that the following amounts of nitrogen are required for the produce named:

1 bushel of oats (grain and straw) requires 1 pound of nitrogen.
1 bushel of corn (grain and stalks) requires 1½ pounds of nitrogen.
1 bushel of wheat (grain and straw) requires 2 pounds of nitrogen.
1 ton of timothy contains 24 pounds of nitrogen.
1 ton of clover contains 40 pounds of nitrogen.
1 ton of cowpeas contains 43 pounds of nitrogen.
1 ton of alfalfa contains 50 pounds of nitrogen.
1 ton of average manure contains 10 pounds of nitrogen.
1 ton of young sweet clover, at about the stage of growth when it is plowed under as green manure, contains, on water-free basis, 80 pounds of nitrogen.

The roots of clover contain about half as much nitrogen as the tops, and the roots of cowpeas contain about one-tenth as much as the tops. Soils of moderate productive power will furnish as much nitrogen to clover (and two or three times as much to cowpeas) as will be left in the roots and stubble. In grain crops, such as wheat, corn, and oats, about two-thirds of the nitrogen is contained in the grain and one-third in the straw or stalks.

The Phosphorus Problem

The element phosphorus is an indispensable constituent of every living cell. It is intimately connected with the life processes of both plants and animals, the nuclear material of the cells being especially rich in this element.

The phosphorus content of a soil varies according to its origin and the kind of farming practiced. Even virgin soils are found that are deficient in phosphorus.

On all lands deficient in phosphorus (except on those susceptible to serious erosion by surface washing or gullying) that element should be applied in considerably larger amounts than are required to meet the actual needs of the crops desired to be produced. The abundant information thus far secured shows positively that finely ground natural rock phosphate can be used successfully and very profitably, and clearly indicates that this material will be the most economical form of phosphorus to use in all ordinary systems of permanent, profitable soil improvement. The first application may well be one ton per acre, and subsequently about one-half ton per acre every four or five years should be applied, at least until the phosphorus content of the plowed soil reaches 2,000 pounds per acre, which may require a total application of from 3 to 5 or 6 tons per acre of raw phosphate containing 12½ percent of the element phosphorus.

Steamed bone meal and even acid phosphate may be used in emergencies, but it should always be kept in mind that a pound of phosphorus delivered in Illinois in the form of raw phosphate (direct from the mine in carload lots), is much cheaper than the same amount in steamed bone meal or in acid phosphate, both of which cost too much per ton to permit their common purchase by farmers in carload lots, which is not the case with raw phosphate. Landowners should bear in mind the fact that phosphorus additions to the soil in amounts above the immediate crop requirements represent a permanent investment, since this element is not readily lost in the drainage water as in the case of nitrogen. It is removed from the farm thru the sale of crops, milk, and animals.

Phosphate may be applied at any time during a rotation, but it is applied to the best advantage either preceding a crop of clover, which plant seems to possess an unusual power for assimilating raw phosphate, or else at a time when it can be plowed under with some form of organic matter such as animal manure or green manure, the decay of which serves to liberate the phosphorus from its insoluble condition in the rock. It is important that the finely ground rock phosphate be intimately mixed with the organic material as it is plowed under.

The Potassium Problem

Normal soils, in which clay and silt form a considerable part of the constituency, are well stocked with potassium, altho it exists largely in insoluble form. Such soils as sands and peats, however, are likely to be low in this element. On such soils this deficiency may be supplied by the application of some potassium salt, such as potassium sulfate, potassium chlorid, kainit, or other potassium compound, and in many instances this is done at great profit.

From all the facts at hand it seems, so far as our great areas of normal soils are concerned, that the potassium problem is not one of addition but of liberation. The Rothamsted records, which represent the oldest soil experiment fields in the world, show that for many years other soluble salts have had practically the same power as potassium to increase crop yields in the absence of sufficient decaying organic matter. Whether this action relates to supplying or liberating potassium for its own sake, or to the power of the soluble salt to increase the availability of phosphorus or other elements, is not known, but where much potassium is removed, as in the entire crops at Rothamsted, with no return of organic residues, probably the soluble salt functions in both ways.

Further evidence on this matter is furnished by the Illinois experiment field at Fairfield, where potassium sulfate has been compared with kainit both with and without the addition of organic matter in the form of stable manure. Both sulfate and kainit produced a substantial increase in the yield of corn, but the cheaper salt—kainit—was just as effective as the potassium sulfate, and returned some financial profit. Manure alone gave an increase similar to that produced by the potassium salts, but the salts added to the manure gave very little increase over that produced by the manure alone. This is explained in part perhaps because the potassium removed in the crops is mostly returned in the manure if properly cared for, and perhaps in larger part because the decaying organic matter helps to liberate and hold in solution other plant-food elements, especially phosphorus.

In laboratory experiments at the Illinois Experiment Station, it has been shown that potassium salts and most other soluble salts increase the solubility of the phosphorus in soil and in rock phosphate; also that the addition of glucose with rock phosphate in pot-culture experiments increases the availability of the phosphorus, as measured by plant growth, altho the glucose consists only of carbon, hydrogen, and oxygen, and thus contains no plant food of value.

In considering the conservation of potassium on the farm it should be remembered that in average live-stock farming the animals destroy two-thirds of the organic matter and retain one-fourth of the nitrogen and phosphorus from the food they consume, but that they retain less than one-tenth of the potassium; so that the actual loss of potassium in the products sold from the farm, either in grain farming or in live-stock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by the actual crop requirements for plant food, magnesium and calcium are more limited in some Illinois soils than potassium. But with these elements we must also consider the loss by leaching.

Doctor Edward Bartow and associates, of the Illinois State Water Survey, have shown that as an average of 90 analyses of Illinois well-waters drawn chiefly from glacial sands, gravels, or till, 3 million pounds of water (about the average annual drainage per acre for Illinois) contained 11 pounds of potassium, 130 of magnesium, and 330 of calcium. These figures are very significant, and it may be stated that if the plowed soil is well supplied with the carbonates of magnesium and calcium, then a very considerable proportion of these amounts will be leached from that stratum. Thus the loss of calcium from the plowed soil of an acre at Rothamsted, England, where the soil contains plenty of limestone, has averaged more than 300 pounds a year as determined by analyzing the soil in 1865 and again in 1905. And practically the same amount of calcium was found by analyzing the Rothamsted drainage waters.

Common limestone, which is calcium carbonate ($CaCO_3$), contains, when pure, 40 percent of calcium, so that 800 pounds of limestone is equivalent to 320 pounds of calcium. Where 10 tons per acre of ground limestone was applied at Edgewood, Illinois, the average annual loss during the next ten years amounted to 790 pounds per acre. The definite data from careful investigations thus seem to indicate that where limestone is needed at least 2 tons per acre should be applied every four or five years.

It is of interest to note that thirty crops of clover of 4 tons each would require 3,510 pounds of calcium, while the most common prairie land of southern Illinois contains only 3,420 pounds of total calcium in the plowed soil of an acre. Thus limestone has a positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

In considering the relation of sulfur in a permanent system of soil fertility it is important to understand something of the cycle of transformations that this element undergoes in nature. Briefly stated this is as follows:

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein. When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals —to air—to soil.

In this way sulfur becomes largely a self-renewing element of the soil, altho there is a considerable loss from the soil by leaching. Observations taken at the Illinois Agricultural Experiment Station show that 40 pounds of sulfur per acre are brought into the soil thru the annual rainfall. With a fair stock of sulfur, such as exists in our common types of soil, and an annual return, which of itself would more than suffice for the needs of maximum crops, the maintenance of an adequate sulfur supply presents little reason at present for serious concern. There are regions, however, where the natural stock of sulfur in the soil is not nearly so high and where the amount returned thru rainfall is small. Under such circumstances sulfur soon becomes a limiting element of crop production, and it will be necessary sooner or later to introduce this substance from some outside source. Investigation is now under way to determine to what extent this situation may apply to conditions in Illinois.

Physical Improvement of Soils

In the management of most soil types, one very important thing, aside from proper fertilization, tillage, and drainage, is to keep the soil in good physical condition, or good tilth. The constituent most important for this purpose is organic matter. Organic matter in producing good tilth helps to control washing of soil on rolling land, raises the temperature of drained soil, increases the moisture-holding capacity of the soil, retards capillary rise and consequently loss of moisture by surface evaporation, and helps to overcome the tendency of some soils to run together badly.

The physical effect of organic matter is to produce a granulation or mellowness, by cementing the fine soil particles into crumbs or grains about as large as grains of sand, which produces a condition very favorable for tillage, percolation of rainfall, and the development of plant roots.

Organic matter is being destroyed during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, corn stalks, weeds, and all or part of the legumes produced on the farm. The amount of legumes needed depends upon the character of the soil. There are farms, especially grain farms, in nearly every community where all legumes could be turned under for several years to good advantage.

Manure should be spread upon the land as soon as possible after it is produced, for if it is allowed to lie in the barnyard several months as is so often the case, from one-third to two-thirds of the organic matter will be lost.

Straw and corn stalks should be turned under, and not burned. Probably no form of organic matter acts more beneficially in producing good tilth than corn stalks. It is true, they decay rather slowly, but it is also true that their durability in the soil is exactly what is needed in the production of good tilth. Furthermore, the nitrogen in a ton of corn stalks is one and one-half times that of a ton of manure, and a ton of dry corn stalks incorporated in the soil will ultimately furnish as much humus as four tons of average farm manure. When burned, however, both the humus-making material and the nitrogen are lost to the soil.

It is a common practice in the corn belt to pasture the corn stalks during the winter and often rather late in the spring after the frost is out of the ground. This tramping by stock sometimes puts the soil in bad condition for working. It becomes partially puddled and will be cloddy as a result. If tramped too late in the spring, the natural agencies of freezing and thawing and wetting and drying, with the aid of ordinary tillage, fail to produce good tilth before the crop is planted. Whether the crop is corn or oats, it necessarily suffers, and if the season is dry, much damage may be done. If the field is put in corn, a poor stand is likely to result, and if put in oats, the soil is so compact as to be unfavorable for their growth. Sometimes the soil is worked when too wet. This also produces a partial puddling which is unfavorable to physical, chemical, and biological processes. The bad effect will be greater if cropping has reduced the organic matter below the amount necessary to maintain good tilth.

Systems of Crop Rotations

In a program of permanent soil improvement one should adopt at the outset a good rotation of crops, including a liberal use of legumes, in order to increase the organic matter of the soil either by plowing under the legume crops and other crop residues (straw and corn stalks), or by using for feed and bedding practically all the crops raised and returning the manure to the land with the least possible loss. No one can say in advance for every particular case what will prove to be the best rotation of crops, because of variation in farms and farmers and in prices for produce.

Following are a few suggested rotations, applicable to the corn belt, which may serve as models or outlines to be modified according to special circumstances.

Six-Year Rotations

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover), or grass and clover
Sixth year —Clover, or clover and grass

Of course there should be as many fields as there are years in the rotation. In grain farming, with small grain grown the third and fifth years, most of the unsalable products should be returned to the soil, and the clover may be clipped and left on the land or returned after threshing out the seed (only the clover seed being sold the fourth and sixth years); or, in live-stock farming, the field may be used three years for timothy and clover pasture and meadow if desired. The system may be reduced to a five-year rotation by cutting out either the second or the sixth year, and to a four-year system by omitting the fifth and sixth years, as indicated below.

Five-Year Rotations

First year —Corn
Second year —Wheat or oats (with clover, or clover and grass)
Third year —Clover, or clover and grass
Fourth year —Wheat (with clover), or clover and grass
Fifth year —Clover, or clover and grass

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover, or clover and grass)
Fourth year —Clover, or clover and grass
Fifth year —Wheat (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover
Fifth year —Wheat (with clover)

The last rotation mentioned above allows legumes to be seeded four times. Alfalfa may be grown on a sixth field for five or six years in the combination rotation, alternating between two fields every five years, or rotating over all the fields if moved every six years.

Four-Year Rotations

First year —Wheat (with clover)
Second year —Corn
Third year —Oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Corn
Third year —Wheat or oats (with clover)
Fourth year —Clover

First year —Corn
Second year —Wheat or oats (with clover)
Third year —Clover
Fourth year —Wheat (with clover)

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with clover)

First year —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

Alfalfa may be grown on a fifth field for four or eight years, which is to be alternated with one of the four; or the alfalfa may be moved every five years, and thus rotated over all five fields every twenty-five years.

Three-Year Rotations

First year —Corn
Second year —Oats or wheat (with clover)
Third year —Clover

First year —Wheat (with clover)
Second year —Corn
Third year —Cowpeas or soybeans

By allowing the clover, in the last rotation mentioned, to grow in the spring before preparing the land for corn, we have provided a system in which legumes grow on every acre every year. This is likewise true of the following suggested two-year system:

Two-Year Rotations

First year —Oats or wheat (with sweet clover)
Second year —Corn

Altho in this two-year rotation either oats or wheat is suggested, as a matter of fact, by dividing the land devoted to small grain, both of these crops can be grown simultaneously, thus providing a three-crop system in a two-year cycle.

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute rye for the wheat or oats. In all of these proposed rotations the word *clover* is used in a general sense to designate either red clover, alsike clover, or sweet clover. The value of sweet clover especially as a green manure for building up depleted soils, as well as a pasture and hay-crop, is becoming thoroly established, and its importance in a crop-rotation program may well be emphasized.

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields Representing the More Important Types of Soil Occurring in DeKalb County)

In the earlier reports of this series it was the practice to incorporate in the body of the report the results of certain experiment fields, for the purpose of illustrating the possibilities of improving the soil of various types. The information carried by such data must, naturally, be considered more or less tentative. As the fields grow older new facts develop, which in some instances may call for the modification of former recommendations. It has therefore seemed desirable to separate this experiment field data from the more permanent information of the soil survey, and embody the same in the form of a supplement to the soil report proper, thus providing a convenient arrangement for possible future revisions as additional data accumulate.

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various types of soil. Altho some of these fields have been discontinued, the large majority are still in operation. It is the present purpose to report the summarized results from certain of these fields which are representative of the types of soil described in the accompanying soil report.

A few general explanations at this point, which apply to all the fields, will relieve the necessity of numerous repetitions in the following pages.

Size and Arrangement

These fields vary in size from less than two acres up to 40 acres or more. They are laid off into series of plots, the plots commonly being either one-fifth or one-tenth acre in area. Each series is occupied by one kind of crop. Usually there are several series so that a crop rotation can be carried on with every crop represented every year.

Farming Systems

On many of the fields the treatment provides for two distinct systems of farming, live-stock farming and grain farming.

In the live-stock system, stable manure is used to furnish organic matter and nitrogen. The amount applied to a plot is based upon the amount that can be produced from crops raised on that plot.

In the grain system no animal manure is used. The organic matter and nitrogen are applied in form of plant manures, including all the plant residues produced, such as corn stalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the live-stock system.

Crop Rotations

Crops which are of interest in the respective localities are grown in definite rotations, and on most of the fields provision is made so that every crop in the rotation is represented every year. The most common rotation used is wheat, corn, oats, and clover; and often these crops are accompanied by alfalfa growing on a fifth series. In the grain system a legume catch crop, usually sweet clover, is included, which is seeded on the young wheat in the spring and plowed under in the fall or in the following spring in preparation for corn. In the event of clover failure, soybeans are substituted.

Soil Treatment

The treatment applied to the plots has, in large part, been standardized according to a rather definite system, altho many deviations from this system occur.

Following is a brief explanation of this standard system of treatment.

Animal Manures.—Animal manures, consisting of excreta from animals, with stable litter, are spread upon the respective plots in amounts proportionate to previous crop yields, the applications being made in the preparation for corn.

Plant Manures.—All crop residues produced on the land, such as stalks, straw, and chaff, are returned to the soil, and in addition a green-manure crop of sweet clover is seeded in small grains to be plowed under in preparation for corn. (On plots where limestone is lacking the sweet clover seldom survives.) This practice is designated as the *residues system.*

Mineral Manures.—The usual yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, the equivalent of 200 pounds of kainit. The initial application of limestone has usually been 4 tons per acre.

Explanation of Symbols Used

0 = Untreated land or check plots
M = Manure (animal)
R = Residues (from crops, and includes legumes used as green manure)
L = Limestone
P = Phosphorus
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

In discussions of this sort of data, financial profits or losses based upon assigned market values are frequently considered. However, in view of the erratic fluctuations in market values—especially in the past few years—it seems futile to attempt to set any prices for this purpose that are at all satisfactory. The yields are therefore presented with the thought that with these figures at hand the financial returns from a given practice can readily be computed upon the basis of any set of market values that the reader may choose to apply.

BROWN SILT LOAM

Several experiment fields have been conducted on brown silt loam soil at various locations in Illinois. Those located at the University have been in operation the longest and they serve well to illustrate the principles involved in the maintenance and improvement of this type of soil.

The Morrow Plots

It happens that the oldest soil experiment field in the United States is located on typical brown silt loam of the early Wisconsin glaciation, on the campus of the University of Illinois. This field was started in 1879 by George E. Morrow, who for many years was Professor of Agriculture, and these plots are known as the Morrow plots.

The Morrow series now consists of three plots divided into halves and the halves are subdivided into quarters. On one plot corn is grown continuously; on the second, corn and oats are grown in rotation; and on the third, corn, oats, and clover are rotated. The north half of each plot has had no fertilizing material applied from the beginning of the experiments, while the south half has been treated since 1904, receiving standard applications of farm manure with cover crops grown in the one-crop and two-crop systems. Phosphorus has been applied in two different forms: rock phosphate to the southwest quarter at the rate of 600 pounds, and steamed bone meal to the southeast quarter at the rate of 200 pounds per acre per year up to 1919, when the rock phosphate was increased sufficiently to bring up the total amount applied to four times the quantity of bone meal applied. At the same time the rate of subsequent application of both forms of phosphorus was reduced to one-fourth the quantity, or to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per year. In 1904 ground limestone was applied at the rate of 1,700 pounds per acre to the south half of each plot, and in 1918 a further application was made at the rate of 5 tons per acre with the intention of standardizing the application to the rate of 1,000 pounds of limestone per acre per year.

Table 1 gives the yearly record of the crop yields, and Table 2 presents the same in summarized form.

FIG. 1.—CORN ON THE MORROW PLOTS IN 1910

TABLE 1.—URBANA FIELD, MORROW PLOTS: BROWN SILT LOAM; PRAIRIE; EARLY WISCONSIN GLACIATION

Crop Yields in Soil Experiments—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
		Corn	Corn	Oats	Corn	Oats	Clover
1879-87	None........	....	....	....	....	....	....
1888	None........	54.3	49.5	....	....	48.6	....
1889	None........	43.2	....	37.4	....	....	(4.04)
1890	None........	48.7	54.3	....	....	....	(1.51)
1891	None........	28.6	33.2	....	....	....	(1.46)
1892	None........	33.1	....	37.2	70.2	....	....
1893	None........	21.7	29.6	....	34.1	....	....
1894	None........	34.8	....	57.2	....	65.1	....
1895	None........	42.2	41.6	....	....	22.2	....
1896	None........	62.3	....	34.5	....	....	....
1897	None........	40.1	47.0	....	....	....	....
1898	None........	18.1	....	....	....	....	....
1899	None........	50.1	44.4	....	53.5	....	....
1900	None........	48.0	....	41.5	....	....	....
1901	None........	23.7	33.7	....	34.3	....	....
1902	None........	60.2	....	56.3	....	54.6	....
1903	None........	26.0	35.9	....	....	....	(1.11)
1904	None........	21.5	....	17.5	55.3	....	....
1904	MLP........	17.1	....	25.3	72.7	....	....
1905	None........	24.8	50.0	....	....	42.3	....
1905	MLP........	31.4	44.9	....	....	50.6	....
1906	None........	27.1	....	34.7	....	....	(1.42)[1]
1906	MLP........	35.8	....	52.4	....	....	(1.74)[1]
1907	None........	29.0	47.8	....	80.5	....	....
1907	MLP........	48.7	87.6	....	93.6	....	....
1908	None........	13.4	....	32.9	....	40.0	....
1908	MLP........	28.0	....	45.0	....	44.4	....
1909	None........	26.6	33.0	....	....	....	(.65)[2]
1909	MLP........	31.6	64.8	....	....	....	(1.73)[3]
1910	None........	35.9	....	33.8	58.6	....	....
1910	MLP........	54.6	....	59.4	83.3	....	....
1911	None........	21.9	28.6	....	....	20.6	....
1911	MLP........	31.5	46.3	....	....	38.0	....
1912	None........	43.2	....	55.0	....	....	16.3[1]
1912	MLP........	64.2	....	81.0	....	....	20.0[1]
1913	None........	19.4	29.2	....	33.8	....	....
1913	MLP........	32.0	25.0	....	47.8	....	....
1914	None........	31.6	....	33.6	....	39.6	....
1914	MLP........	39.4	....	58.2	....	60.4	....
1915	None........	40.0	49.0	....	....	....	24.2[1]
1915	MLP........	66.0	81.2	....	....	....	27.1[1]
1916	None........	11.2	....	37.5	27.8	....	....
1916	MLP........	10.8	....	64.7	40.6	....	....
1917	None........	40.0	48.4	....	....	68.4	....
1917	MLP........	78.0	81.4	....	....	86.9	....
1918	None........	13.6	....	27.2	....	....	(2.58)
1918	MLP........	32.6	....	59.3	....	....	(4.04)
1919	None........	24.0	30.8	....	52.2	....	....
1919	MLP........	43.4	66.2	....	70.8	....	....
1920	None........	28.2	....	37.2	....	52.2	....
1920	MLP........	54.4	....	51.6	....	69.7	....
1921	None.......	19.8	30.6	....	....	....	(.26)[4]
1921	MLP.......	42.2	68.4	...	....	....	(1.33)[5]

[1]Soybeans.
[2]In addition to the hay, .64 bushel of seed was harvested.
[3]In addition to the hay, 1.17 bushels of seed were harvested.
[4]In addition to the hay, .53 bushel of seed was harvested.
[5]In addition to the hay, .85 bushel of seed was harvested.

TABLE 2.—URBANA FIELD, MORROW PLOTS: GENERAL SUMMARY
Average Annual Yields—Bushels or (tons) per acre

Years	Soil treatment applied	Corn every year	Two-year rotation		Three-year rotation		
			Corn	Oats	Corn	Oats	Clover
		16 crops	*9 crops*	*6 crops*	*4 crops*	*4 crops*	*4 crops*
1888 to 1903	None........	39.7	41.0	44.0	48.0	47.6	(2.03)
		18 crops	*9 crops*	*9 crops*	*6 crops*	*6 crops*	*4 crops*
1904 to 1921	None........	26.2	38.6	34.4	51.4	43.9	(1.23)[1]
	MLP........	41.2	62.9	55.2	68.1	58.3	(2.21)[1]

[1]One crop of soybean hay.

Summarizing the data from these Morrow plots into two periods with the second period beginning in 1904 when the treatment began on the half-plots, some interesting comparisons may be made. In the first place we find in the continuous corn plot a marked decrease in the second period in the average yield of corn, amounting to one-third of the crop. In the two-year rotation there is a decrease in both corn and oats production, while the averages for the three-year system show an increase in corn yield and decreases in oats and clover. Unfortunately the numbers of crops included in these last averages are too small to warrant positive conclusions.

The increase brought about by soil treatment stands out in all cases, showing the possibility not only of restoring but also of greatly improving the productive power of this land that has been so abused by continuous cropping without fertilization.

The Davenport Plots

Another set of plots on the University campus at Urbana, forming a more extensive series than the Morrow plots, but of more recent origin, are the Davenport plots. Here each crop in the rotation is represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

From 1901 to 1911 three of the series were in a three-year rotation system of corn, oats, and clover, while the remaining two series rotated in corn and oats. In 1911 these two systems were combined into a five-series field, with a crop rotation of wheat, corn, oats, and clover, with alfalfa on a fifth field. The alfalfa occupies one series during a rotation of the other four crops, shifting to another series in the fifth year, thus completing the cycle of all series in twenty-five years.

The soil treatment applied to these plots has been as follows:

Legume cover crops were seeded in the corn at the last cultivation on Plots 2, 4, 6, and 8, from 1902 to 1907, but the growth was small and the effect, if any, was to decrease the returns from the regular crops. Crop residues (**R**) have been returned to these same plots since 1907. These consist of stalks and straw, and all legumes except alfalfa hay and the seed of clover and soybeans. Beginning in 1918 a modification of the practice was made in that one cutting of the red clover crop is harvested as hay. In conjunction with these residues a catch crop of sweet clover grown with the wheat is plowed under.

Manure (**M**) was applied preceding corn, at the rate of 2 tons per acre per year in 1905, 1906, and 1907; subsequently as many tons have been applied as there have been tons of air-dry produce harvested from the respective plots.

Lime (**L**) was applied on Plots 4 to 10 at the rate per acre of 250 pounds of air-slaked lime in 1902, and 600 pounds of limestone in 1903. No further application was made until 1911, when the system of cropping was changed. Since that time applications of limestone have been made at the rate of one-half ton per acre per year.

Phosphorus (**P**) was applied on Plots 6 to 9 at the rate of 25 pounds per acre per annum in 200 pounds of steamed bone meal; but beginning with 1908 rock phosphate at the rate of 600 pounds per acre per annum was substituted for the bone meal on one-half of each of these plots. These applications continued until 1918 when adjustments were begun, first to make the rate of application of rock phosphate four times that of the bone meal, and finally to reduce the amounts of these materials to 200 pounds of rock phosphate and 50 pounds of bone meal per acre per annum. The usual practice has been to apply and plow under at one time all phosphorus and potassium required for the rotation.

Potassium (**K** = kalium) has been applied on Plots 8 and 9, in connection with the organic manures and phosphorus, at the yearly rate of 42 pounds per acre, and mainly as potassium sulfate.

On Plot 10 about five times as much manure and phosphorus are applied as on the other plots, but this "extra heavy" treatment was not begun until 1906, only the usual amounts of lime, phosphorus, and potassium having been applied in previous years. The purpose in making these heavy applications is to try to determine the climatic possibilities in crop yields by removing the limitations of inadequate fertility.

It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues along with legumes, is exemplified in Plots 2, 4, 6, and 8; and the *live-stock system,* in which farm manure is utilized for soil enrichment, is represented in Plots 3, 5, 7, and 9.

Table 3 shows a summary of the results obtained on the Davenport plots beginning with the year 1911, when the present cropping system was introduced.

When used in conjunction with phosphorus the crop residues and the manure appear about equally effective; but where phosphorus is not applied, the manure has been decidedly more effective, under the conditions of the experiment. It should be observed, however, in this connection, that the plowing under of clover is a very essential feature of the residues system, and that, as a matter of fact, there were five clover failures, when soybeans were substituted, during the ten years. Perhaps with a more reliable biennial legume than red clover, the results would have been more favorable for this system.

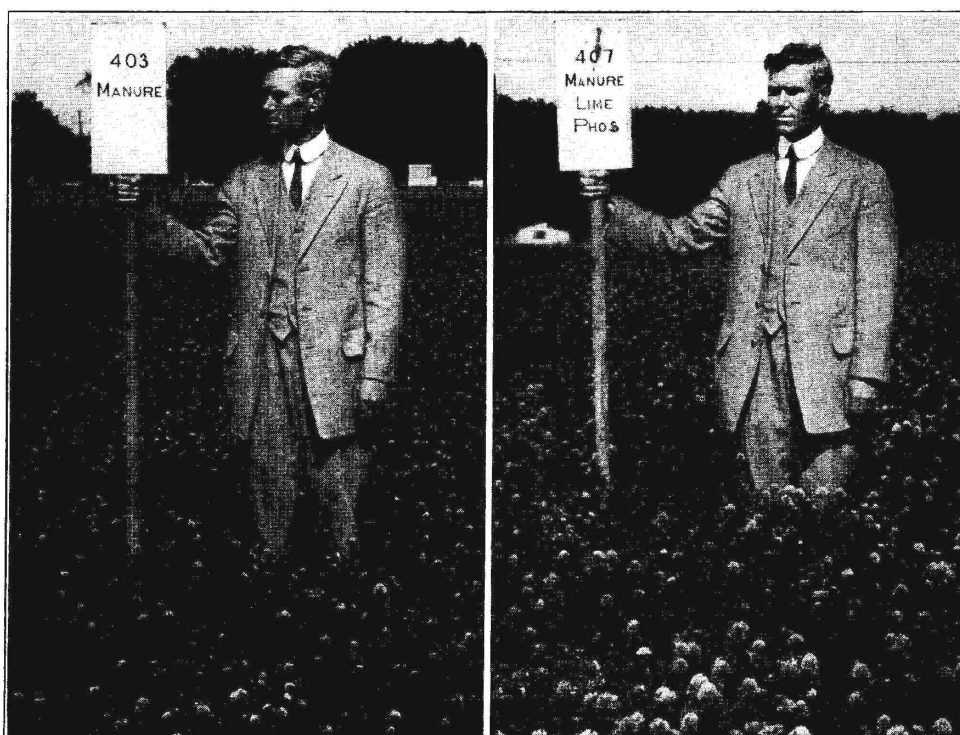
By comparing Plots 2 and 3 with Plots 4 and 5, it is found that limestone has had a beneficial effect on all crops. What the financial profit amounts to depends obviously upon the market value of the crops and the cost of the limestone.

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION
Average Annual Yields—Bushels or (tons) per acre
1911–1920

Serial plot No.	Soil treatment applied	Corn	Oats	Wheat	Clover 5 crops	Soybeans 5 crops	Alfalfa
1	0	55.6	50.5	26.0	(2.42)	(1.47)	(2.43)
2	R	57.1	52.3	28.7	1.47[1]	19.8	(2.46)
3	M	66.3	61.9	28.2	(2.56)	(1.62)	(2.52)
4	RL	64.8	55.6	31.4	1.61[1]	20.3	(2.72)
5	ML	69.6	64.1	32.8	(2.90)	(1.67)	(3.03)
6	RLP	71.5	69.8	43.0	2.29[1]	23.5	(3.69)
7	MLP	73.0	68.6	40.0	(3.52)	(1.97)	(3.76)
8	RLPK	70.9	72.5	40.7	1.79[1]	25.5	(3.77)
9	MLPK	70.2	72.0	39.2	(3.40)	(2.20)	(3.73)
10	Mx5LPx5	65.9	71.4	40.6	(3.31)	(2.22)	(3.77)

[1]In addition to the clover seed, a crop of hay was harvested one year on Plots 2, 4, 6, and 8, yielding 2.38, 2.20, 2.54, and 2.39 tons respectively.

Comparing Plots 4 and 5 with Plots 6 and 7, respectively, there is found in all cases an increase in crop yield as a result of adding phosphorus. The effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 17 bushels of wheat, over the yield of the untreated land, has been obtained as a ten-year average.



Manure
Yield: 1.43 tons per acre

Manure, limestone, phosphorus
Yield: 2.90 tons per acre

FIG. 2.—CLOVER ON THE DAVENPORT PLOTS IN 1913

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are the same as Plots 6 and 7, respectively, except that potassium has been applied to the former. On the whole, no significant benefit is shown from the addition of potassium.

No benefit appears as the result of the extra-heavy applications of manure and phosphorus on Plot 10. In fact the corn yields are noticeably less here than on the plots receiving the normal applications of these materials.

The University South Farm

On the University South Farm, at Urbana, several series of plots devoted primarily to variety testing and other crop-production experiments are so laid out as to show the effects of certain soil treatments that have been applied. Several different systems of crop rotation are employed and the crops are so handled as to exemplify the two general systems of farming, grain and live-stock.

The summarized results presented in Table 4 represent three different systems of cropping. The first, designated as the Southwest rotation, is to be regarded as a good rotation for general practice, on this type of soil, under Illinois conditions. This is a four-field rotation of wheat, corn, oats, and clover.

TABLE 4.—URBANA FIELD, SOUTH FARM: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre
1908-1919

Southwest Rotation: Series 100, 200, 400[1]: Wheat, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 9 crops	Oats[3] 9 crops	Wheat[3] 8 crops	Clover[4] 3 crops	Soybeans 7 crops
RP	62.3	51.9	41.0	1.05	17.3[5]
R	51.9	46.5	26.9	1.38	16.2[5]
M	59.7	50.2	29.1	(2.28)	(1.25)
MP	64.3	55.4	43.1	(2.86)	(1.51)
RLP	60.5	57.2	41.8	.64	16.4[5]
R	49.7	49.6	25.8	.83	14.7[5]
M	55.5	54.1	27.8	(1.71)	(1.28)
MLP	64.1	59.6	43.9	(1.77)	(1.58)

North-Central Rotation: Series 500, 600, 700[1]: Corn, Corn, Oats, Clover[2]

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Oats 9 crops	Clover 5 crops	Soybeans 4 crops
RP	56.7	51.1	56.1	.54	16.9
R	51.7	45.2	52.0	.50	16.0
M	54.9	46.7	52.1	(2.29)	(1.60)
MP	56.5	53.4	56.9	(2.73)	(1.74)

South-Central Rotation: Series 500, 600, 700[1]: Corn Corn, Corn, Soybeans

Soil treatment applied[6]	Corn 1st year 9 crops	Corn 2d year 9 crops	Corn 3d year 9 crops		Soybeans 9 crops
RP	51.9	44.0	41.3		20.0
R	45.5	39.9	35.2		19.2
M	50.1	42.1	38.5		(1.59)
MP	54.5	46.7	42.0		(1.66)

[1]Results from Series 300 and 800 are omitted on account of variation in soil type.
[2]Soybeans when clover fails.
[3]Only seven crops with limestone.
[4]Only one crop with limestone.
[5]Average of five crops.
[6]All phosphorus plots received ½ ton per acre of limestone in 1903.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
YIELDS FROM PLOTS ON THE UNIVERSITY SOUTH FARM

Twelve-Year Average (1908–1919)—Bushels per acre

Rotation	Wheat-corn-oats-legume[1]	Corn-corn-oats-legume[2]		Corn-corn-corn-legume[3]		
Treatment	Corn	1st Corn	2d Corn	1st Corn	2d Corn	3d Corn
Organic manures..............	55.8	53.3	46.0	47.8	41.0	34.3
Organic manures, phosphorus...	63.2	56.6	52.3	53.2	45.3	41.6

[1]Clover 3 crops and soybeans 7 crops.
[2]Clover 5 crops, and soybeans 5 crops.
[3]Soybeans 9 crops.

The second, or North-Central rotation, consisting of corn, corn, oats, and clover, represents a system very commonly practiced; and the third or South-Central rotation, consisting of corn, corn, corn, and soybeans, must be considered as a poor rotation from the standpoint of maintaining the productiveness of the land.

On the whole, the "residues" have not returned yields quite so high as those produced by the manure treatment; but, as remarked above in the discussion of the Davenport plots, the residues system has probably been at a disadvantage thru frequent clover failures. On the North-Central rotation, where conditions seem to have been more favorable for clover, there is very little difference between the effect of manure and of residues.

Residues plowed under
Yield: 35.2 bushels per acre

Residues and rock phosphate
Yield: 50.1 bushels per acre

FIG. 3.—WHEAT ON THE UNIVERSITY SOUTH FARM IN 1911

In the rotation system in which limestone is being applied, no benefit of consequence to any of the crops except oats appears from the use of this material. The test, however, has hardly been of sufficient duration to warrant final conclusions; and furthermore, the comparison may be somewhat impaired by a possible residual effect of the small application of limestone made in 1903 to all the phosphorus plots.

The results obtained from the use of phosphorus are important because this element has been applied to these plots solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphorus has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records furnish some interesting comparisons of corn yields produced under different systems of cropping. Table 5 gives a general summary of the corn yields only, in which the results from the residues and manure treatments are averaged together as "organic manures." The highest annual acre-yields are found where corn occurs but once in a rotation. Where corn is grown twice in succession, the annual acre-yields are less; and where corn occurs three times, there is a further reduction. Also, the first crop of corn within a rotation produces more than the second, and the second crop yields more than the third. These are useful facts for consideration in connection with problems of general farm management.

The DeKalb Field

An experiment field located in DeKalb county on the brown silt loam type of soil, just south of the city of DeKalb, has been in operation since 1906. This field was established primarily as a crops experiment field where the investigations relate to such matters as methods of seeding, cultivation, care, handling, and tests of varieties of our common field crops. Incidentally, however, the effects of certain soil treatments on these plots are compared. It is the present purpose to consider only those results that have to do directly with these soil treatments. The results of the strictly crops experiments are presented from time to time in other appropriate bulletins.

The diagram presented as Fig. 4 shows the arrangement of the plots, the system of numbering, the plan of soil treatment, and the cropping systems employed.

Arrangement of Plots.—The plots lie in four series, which number in hundreds from north to south. Each series has two divisions, an east and a west. Each division consists of 18 plots. These plots number from west to east according to the system indicated in the diagram on the 100 series. The plots of the 100 series are one-tenth acre in size, while those on the other series are one-fifth acre.

Standard Plots.—All plots corresponding to the numbers 3, 6, 9, 10, 13, and 16 are called standard plots; that is, the variety, or whatever the test may be aside from soil treatment, is alike on all of these six plots for any one division.

Soil Treatment.—In order to maintain the productiveness of the field, fertilizing materials are applied and definite systems of crop rotation are employed

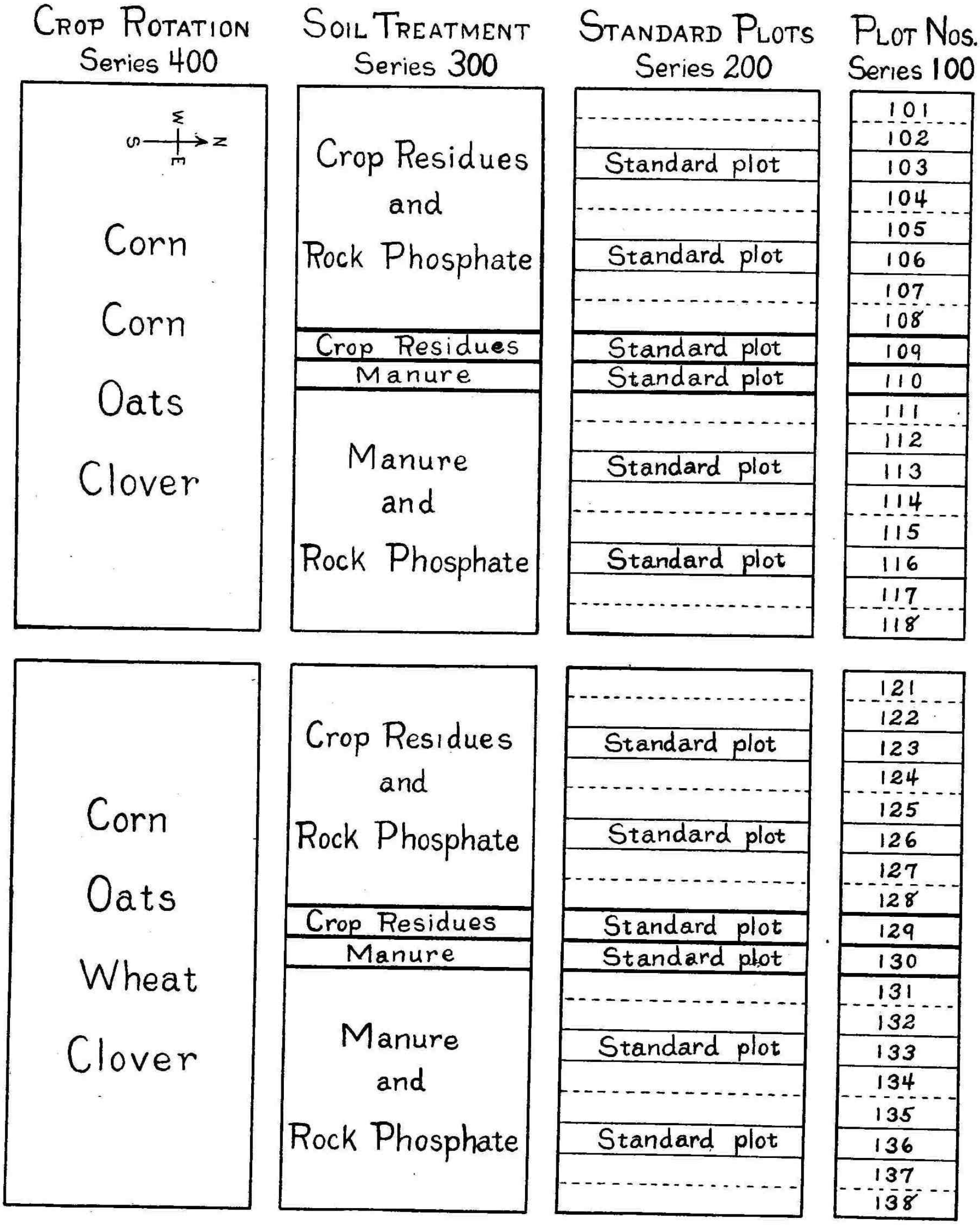


FIG. 4.—DIAGRAM OF DEKALB EXPERIMENT FIELD, SHOWING THE ARRANGEMENT OF PLOTS, THE SYSTEMS OF CROPPING, AND THE TREATMENTS APPLIED

as explained below, the crops being handled so as to exemplify the two systems of farming, grain and live stock. The plots comprizing the west half of each division represent grain farming. They receive no farm manure, but residues are returned to the soil. On the east half of each division, live-stock farming is represented, and here farm manure is applied in proportion to the crops produced. Raw rock phosphate is applied to all plots except the soil check plots (Nos. 9 and 10).

Soil Check Plots.—In the middle of every division two plots corresponding to the numbers 9 and 10 serve as check plots to test the effect of the phosphorus treatment. Plot 9 receives the crop residues produced and Plot 10 receives stable manure. Neither of these plots receives phosphate.

Rotation Systems.—The west half of the field, embracing the four west divisions of all four series, is farmed under a rotation of corn, corn, oats, and alsike clover. The east divisions of the series are in a rotation of corn, oats, wheat, and alsike clover. In the event of clover failure soybeans are substituted.

Tables 6 and 7 show the yield of each crop since the beginning of the experiments, and Table 8 gives a summary of these results, exclusive of those obtained in the beginning before full treatment was under way. Because of certain abnormalities in Plots 116 and 123 the data from these plots are excluded from the summary.

In looking over these records the beneficial effects of farm manure stand out prominently, thus emphasizing the importance of carefully conserving and regularly applying all available animal manures. Perhaps the fact next in interest to be noted is that the residues plots, with phosphorus applied, have returned yields almost as high as those from the manure plots. In considering this comparison it should be borne in mind that on these manure plots farm manure has been applied regularly at the rate of about 9 tons per acre every rotation, a practice quite impossible to carry out on every farm. It is possible, however, on every farm to sow clover and to return to the land the unconsumed crop residues, and this is the recourse for the farmer who cannot obtain animal manures in quantities sufficient to meet the demand of the land.

The profitable use of rock phosphate has been thoroly demonstrated on many farms in DeKalb county and if it seems surprising on first view that this material has not given greater returns on the DeKalb experiment field than the records show, the reader should take into full account the conditions involved as explained below.

In considering the results for rock phosphate on the DeKalb field, it should be explained at the outset that the soil of this field is considerably richer in phosphorus than the average brown silt loam, the analysis showing over 1,600 pounds per acre of this element in the surface stratum. A study of the summarized data shows some gain for rock phosphate in every crop excepting the clover seed in one of the crop rotation systems. In general these gains are more pronounced in the residues system than where applied with animal manure, which is not surprising since the manure itself carries back to the land a large share of the phosphorus removed in the grain.

It is to be observed further that phosphorus has been more effective in that rotation system which includes corn, oats, wheat, and clover than in the one

TABLE 6.—DEKALB FIELD: BROWN SILT LOAM PRAIRIE; EARLY WISCONSIN GLACIATION
ROTATION: CORN, OATS, WHEAT, CLOVER
Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1906 Corn	1907 Oats	1908 Wheat	1909 Clover	1910 Corn	1911 Oats	1912 Oats	1913 Clover	1914 Corn	1915 Oats	1916 Wheat	1917 Clover	1918 Corn	1919 Oats	1920 Wheat
123	RP.......	67.4	30.0	27.7	0.00	48.2	15.0	42.3	0.00	81.5	49.8	35.2	0.00	58.8	47.7	31.8
126	RP.......	92.8	35.6	38.5	0.00	70.9	12.2	41.1	0.00	84.1	51.2	43.4	0.00	62.0	45.5	31.8
129	R........	67.3	33.4	37.3	0.00	63.9	18.1	55.9	0.00	61.3	40.7	35.1	0.00	57.2	41.4	26.6
130	M........	69.3	33.8	33.0	(.60)	61.1	17.6	64.6	(.92)	69.4	26.9	29.3	(.92)	57.3	41.1	28.5
133	MP......	76.8	39.1	43.0	(.90)	61.5	19.7	72.9	(1.96)	79.0	33.1	29.9	(.85)	57.0	38.8	36.8
136	MP......	72.0	35.0	41.8	(.90)	57.9	14.0	78.1	(1.96)	77.7	36.9	28.0	(.81)	57.0	42.7	36.8
		Oats	Wheat	Clover	Corn	Oats	Wheat	Soybeans	Corn	Oats	Wheat	Clover	Corn	Oats	Wheat	Clover
223	RP.......	22.9	18.6	(2.92)	64.2	71.0	29.0	0.00	55.4	47.4	39.9	0.00	17.4	63.0	19.3	.50
226	RP.......	26.1	19.0	(2.90)	76.8	74.0	33.0	0.00	52.7	50.4	42.7	0.00	17.0	66.3	20.4	.70
229	R........	24.1	14.6	(2.32)	59.8	76.2	25.9	0.00	59.0	44.6	39.0	0.00	8.8	71.8	17.3	.90
230	M........	26.4	19.3	(2.55)	70.2	81.0	34.8	(1.40)	63.3	45.4	39.2	(2.25)	16.7	73.9	19.6	(2.30)
233	MP......	38.0	20.7	(2.67)	75.5	80.3	37.0	(1.40)	68.3	49.2	45.0	(2.56)	23.1	61.2	19.8	(2.46)
236	MP......	36.9	22.7	(2.45)	72.0	79.5	36.7	(1.90)	65.4	45.7	38.6	(2.56)	27.6	69.6	26.0	(2.24)
		Oats	Clover	Corn	Oats	Wheat	Clover	Corn	Oats	Wheat	Clover	Corn	Oats	Wheat	Clover	Corn
323	RP.......	27.9	(1.66)	55.9	70.1	31.2	0.00	67.2	57.4	39.0	0.00	48.6	87.0	24.4	2.91	56.0
326	RP.......	24.9	(1.66)	59.6	65.4	33.4	0.00	66.8	64.1	41.0	0.00	46.8	85.9	26.3	2.67	56.0
329	R........	25.4	(1.30)	39.2	73.3	25.6	0.00	54.4	54.0	25.4	0.00	38.5	80.7	21.1	2.50	43.4
330	M........	26.1	(1.30)	75.4	68.4	38.9	(.80)	69.9	66.4	33.5	(1.92)	50.7	77.1	20.4	(1.76)	61.4
333	MP......	22.8	(1.90)	67.1	74.6	39.0	(1.46)	67.9	71.9	37.2	(2.19)	52.6	78.3	22.2	(1.97)	57.4
336	MP......	23.6	(1.90)	72.6	67.3	45.9	(1.46)	66.8	71.7	39.5	(2.19)	54.7	74.5	29.0	(1.90)	57.4
		Soybeans[1]	Corn	Oats	Oats	Clover	Corn	Oats	Wheat	Clover	Corn	Oats	Wheat	Clover	Corn	Oats
423	RP.......	....	43.9	36.2	61.4	0.00	81.0	81.3	35.4	3.29	32.4	68.8	25.4	1.24	70.1	80.7
426	RP.......	....	45.3	31.7	59.4	0.00	80.0	77.6	33.1	3.29	38.7	64.8	30.7	1.28	73.3	80.7
429	R........	....	43.5	37.3	66.1	0.00	76.4	77.8	27.7	4.50	30.9	62.5	25.2	1.33	62.3	68.8
430	M........	....	58.1	42.8	72.3	(3.10)	76.8	75.0	36.0	(2.68)	42.4	66.5	25.4	(2.21)	68.5	82.7
433	MP......	....	50.9	43.9	69.4	(3.08)	83.5	75.0	41.2	(3.05)	39.4	71.6	33.6	(2.68)	74.9	83.6
436	MP......	....	50.8	41.2	59.5	(3.08)	86.7	71.3	37.2	(3.05)	47.1	73.7	34.7	(2.56)	71.4	83.6

[1]Yields not taken.

Table 7.—DeKalb Field: Brown Silt Loam Prairie; Early Wisconsin Glaciation
Rotation: Corn, Corn, Oats, Clover
Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1906 Corn	1907 Corn	1908 Oats	1909 Clover	1910 Corn	1911 Corn	1912 Oats	1913 Clover	1914 Corn	1915 Corn	1916 Oats	1917 Clover	1918 Corn	1919 Corn	1920 Oats
103	RP.......	74.8	33.0	44.1	0.00	58.9	62.4	76.6	0.00	69.6	37.8	68.4	0.0	51.7	56.2	49.5
106	RP.......	76.2	37.8	40.9	0.00	62.4	64.1	76.1	0.00	78.3	39.7	63.9	0.0	57.9	64.1	49.5
109	R........	73.0	35.3	44.1	0.00	55.7	54.5	63.1	0.00	68.4	33.3	62.1	0.0	47.1	56.1	50.2
110	M........	72.8	35.5	40.6	(1.80)	54.2	56.0	66.2	(1.26)	78.7	30.4	69.1	(.79)	55.0	52.8	63.8
113	MP......	66.0	30.4	45.6	(2.40)	58.6	59.3	74.1	(1.74)	76.9	39.6	66.6	(.59)	53.2	64.1	66.1
116[1]	MP......	51.6	0.0	28.1	(2.00)	45.2	0.0	60.5	(1.74)	79.7	33.3	54.4	(.52)	62.9	64.6	66.1
		Corn	Oats	Clover	Corn	Corn	Oats	Soy-beans	Corn	Corn	Oats	Clover	Corn	Corn	Oats	Clover
203	RP.......	64.6	28.1	(2.45)	56.8	48.4	38.6	(.45)	58.3	50.4	68.5	0.00	17.2	51.3	62.1	2.90
206	RP.......	66.6	28.7	(2.87)	47.1	45.2	39.2	(.90)	61.2	58.0	69.2	0.00	16.0	48.5	53.3	3.70
209	R........	76.4	30.3	(2.40)	59.2	53.9	37.8	(1.20)	68.4	64.9	61.4	0.00	16.9	46.3	60.1	2.80
210	M........	72.4	29.0	(2.60)	68.5	56.8	37.8	(1.10)	63.0	65.6	57.5	(1.84)	21.3	48.6	57.1	(1.94)
213	MP......	45.4	28.1	(2.25)	66.5	52.7	26.9	(0.00)[2]	64.1	62.8	54.0	(1.82)	19.4	46.0	52.7	(1.84)
216	MP......	76.0	28.9	(2.32)	63.0	46.4	27.0	(0.00)[2]	58.8	62.5	64.6	(1.82)	22.2	43.5	49.9	(1.67)
		Oats	Clover	Corn	Corn	Oats	Clover	Corn	Corn	Oats	Clover	Corn	Corn	Oats	Soy-beans	Corn
303	RP.......	23.6	(1.38)	66.1	55.1	68.3	0.00	63.7	54.4	53.2	2.00	46.1	11.3	83.5	15.9	49.1
306	RP.......	21.9	(1.38)	67.8	58.2	84.5	0.00	68.0	60.1	49.1	2.00	44.6	13.9	70.9	17.2	52.7
309	R........	25.3	(1.25)	66.0	58.2	76.1	0.00	57.6	59.1	47.7	3.70	43.4	9.0	79.7	16.9	46.0
310	M........	24.9	(1.45)	73.3	55.4	71.9	(1.30)	63.7	60.0	42.5	(1.59)	51.6	7.3	77.7	(1.26)	58.6
313	MP......	24.6	(1.69)	69.2	52.8	80.9	(1.50)	83.1	53.4	43.2	(1.88)	53.0	11.2	74.9	(1.28)	88.6
316	MP......	23.7	(1.69)	70.8	54.5	82.7	(1.50)	78.2	55.3	43.4	(1.88)	47.0	8.8	73.0	(1.54)	60.8
		Cow-peas[3]	Corn	Corn	Oats	Clover	Corn	Corn	Oats	Clover	Corn	Corn	Oats	Clover	Corn	Corn
403	RP.......	....	53.0	43.9	37.5	0.00	78.6	52.4	43.2	3.12	40.5	40.3	67.5	1.49	56.6	44.9
406	RP.......	....	54.9	46.5	43.8	0.00	75.8	60.2	43.6	3.12	44.0	45.7	78.6	1.42	55.4	50.1
409	R........	....	47.7	30.9	50.8	0.00	49.7	39.5	33.6	1.29	26.5	37.9	67.6	.61	48.7	42.6
410	M........	....	65.8	50.9	60.1	(2.44)	63.1	56.7	39.7	(2.54)	35.9	42.2	85.3	(1.51)	62.3	52.7
413	MP......	....	73.5	55.1	69.0	(3.41)	73.7	67.7	51.1	(3.32)	37.5	47.8	94.2	(1.96)	53.8	62.9
416	MP......	....	74.3	54.3	67.3	(3.41)	72.3	62.4	54.7	(3 32)	44 4	45.4	93.1	(1.83)	53.6	59.9

[1]Alkali spot. [2]Growth practically all weeds. [3]Yields not taken.

TABLE 8.—DE KALB FIELD: SUMMARY

Average Annual Yields—Bushels or (tons) per acre
1909–1920

Soil treatment applied	Crop rotation: corn, oats, wheat, clover				Crop rotation: corn, corn, oats, clover			
	Corn	Oats[1]	Wheat[2]	Clover[3]	Corn	Corn	Oats	Clover[3]
Residues, phos........	59.8	59.9	32.7	0.66	54.6	48.9	59.9	1.02
Residues.............	51.3	59.4	26.9	0.77	49.0	46.3	57.5	.94
Manure, phos.........	61.7	62.4	34.7	(2.05)	59.0	50.9	63.2	(1.81)
Manure..............	59.0	61.4	30.6	(1.74)	56.3	48.7	60.7	(1.61)

[1]Average of 14 crops, oats being substituted when wheat failed.
[2]Average of 10 crops, oats being substituted when wheat failed.
[3]Soybean hay reckoned as equivalent to clover hay; soybean seed reckoned at 1/10 the equivalent of clover seed.

consisting of corn, corn, oats, and clover. In the former cropping system rock phosphate has returned a good financial profit reckoned at the prices prevailing during the years in which these results were obtained. In the latter rotation system, however, in which wheat does not appear, the gain from the increases in yield due to phosphate is just about offset by the expense involved. When considered from the standpoint of permanent fertility, however, the fact should not be overlooked that, in either system, thru the phosphate applications, the soil has not only been protected from loss of phosphorus in crops removed, but it has actually been enriched in this element by the excess provided in the liberal amount of phosphate used.

On the whole these results are of interest in indicating that there may exist here and there an exceptional spot of brown silt loam which, under all circumstances, will not respond in the usual striking manner to phosphorus treatment. In such an instance perhaps the more economical procedure would be to defer for a time phosphorus treatment in favor of more urgent needs of the land without ignoring the fact, however, that the time will inevitably come when the supply of phosphorus will become depleted unless timely provision be made for the replenishment of this element.

YELLOW-GRAY SILT LOAM

Yellow-gray silt loam exhibits an important variation with respect to limestone content. In some areas, altho limestone may be altogether absent in the surface stratum it is found in abundance at a short distance beneath the surface. Accordingly, variations in response to soil treatment are exhibited by different experiment fields located on this type. In view of this discrepancy it is thought well to introduce here the records of two fields, that are representative of the type but which show a marked diversity in results, one in northern Illinois and one in the southern part of the state.

The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. These elements were all applied in commercial form until

1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds of dried blood per acre. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

Table 9 presents, in summarized form, the results from the Antioch field. Because of an abnormality in Plot 1, the results from this plot are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the

Table 9.—ANTIOCH FIELD: Yellow-Gray Silt Loam, Timber Soil; Late Wisconsin Glaciation

Average Annual Yields—Bushels or (tons) per acre
1902-1921

Serial plot No.	Soil treatment applied	Corn 8 crops	Oats 5 crops	Wheat 4 crops	Clover[1] 3 crops
1	0	23.9	32.3	15.8	1.33
2	L	21.3	26.8	13.2	1.26
3	LR	21.3	29.9	20.6	1.45
4	LP	30.7	43.6	36.7	1.61
5	LK	23.7	27.8	19.2	1.21
6	LRP	33.8	43.3	33.3	1.13
7	LRK	24.3	26.9	20.8	1.22
8	LPK	25.1	38.2	30.9	1.51
9	LRPK	38.3	42.6	28.0	1.00
10	RPK	38.4	44.7	30.2	1.28

[1] These figures represent the average combined yields of hay and seed, expressed as the equivalent of clover hay.

Lime applied and residues plowed under — Lime and phosphorus applied

Fig. 5.—Clover in 1913 on Antioch Field

results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

The Raleigh experiment field is located on the lower Illinoisan glaciation, in southern Illinois, in Saline county. This field is laid out into four series of ten plots each, under a rotation of wheat, corn, oats, and clover. The treatments, along with the summarized results, are given in Table 10.

The outstanding feature of these results is the effect of limestone. Altho manure alone produces a substantial increase, especially in the corn crop, when

Manure, limestone, phosphorous
Yield: 61 bushels per acre

Nothing applied
Yield: 15 bushels per acre

FIG. 6.—CORN ON RALEIGH FIELD IN 1920

TABLE 10.—RALEIGH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LOWER ILLINOISAN GLACIATION

Average Annual Yields—Bushels or (tons) per acre
1911-1921

Serial plot No.	Soil treatment applied	Corn 11 crops	Oats 11 crops	Wheat 7 crops	Legumes[1] 9 crops
1	0	15.8	10.2	6.2	(.42)
2	M	27.6	12.5	7.9	(.55)
3	ML	39.0	19.6	21.7	(1.14)
4	MLP	40.0	19.8	22.5	(1.36)
5	0	16.4	10.0	7.3	(.14)
6	R	19.4	12.8	8.8	(.19)
7	RL	34.3	21.2	19.7	(.71)
8	RLP	36.7	22.4	22.4	(.81)
9	RLPK	42.7	23.0	23.8	(.81)
10	0	20.2	11.2	6.9	(.30)

[1] These figures represent the average combined yields of clover and soybeans, whether hay or seed, expressed as the equivalnt of clover hay.

limestone is added a remarkable increase is found in all crops. A most important fact is that the organic matter can be effectively built up thru the use of crop residues, with the application of limestone, so that the crop yields are practically as high under this "grain system" of farming as where manure is used.

Phosphorus thus far has given only moderate returns in increased crop yields, but with an increasing quantity of organic matter and nitrogen it is probable that the phosphorus applications will show up more favorably on subsequent crops. As to the use of potassium, it is to be noted that aside from an increase of 6 bushels of corn in the residues system, the beneficial effect has not been sufficient to justify the use of this material.

In accounting for the discrepancy in the response to limestone on these two fields, the fact is to be considered that the Antioch field is located on the late Wisconsin glaciation, where the subsoil contains large quantities of limestone; while the Raleigh field represents the lower Illinoisan glaciation, the soil of which is very acid to a great depth.

In view of these variations, a general recommendation for a complete treatment for soil of this type, that will apply to all localities, cannot be given out until more information is acquired.

Fortunately, however, each farmer can determine for himself the need of limestone for his land by applying the simple tests for the presence of carbonates and soil acidity, as explained under the discussion of limestone on pages 28 and 29 of the Appendix.

Phosphorus, which has paid well on the Antioch field, and has given doubtful returns thus far at Raleigh, has varied considerably in its effect when used on other fields located on this same type of soil. In this situation, therefore, the present suggestion would be that each farmer might well try out phosphorus on his own land, on a limited scale, and be guided by the outcome of his experience. The low phosphorus content of the surface stratum of this soil is an indication that in a system of permanent agriculture the time is not far off when phosphorus will become a limiting element to crop production, and the wise farmer will watch carefully the indications and be ready to make timely provision for this need.

Deep Peat

As representing the deep peat type of soil, the results are introduced from an experiment field conducted at Manito in Mason county during the years 1902 to 1905 inclusive.

There were ten plots receiving the treatments indicated in Table 11.

The results of the four years' tests, as given in Table 11, are in complete harmony with the information furnished by the chemical composition of peat soil. Where potassium was applied, the yield was from three to four times as large as where nothing was applied. Where approximately equal money values of kainit and potassium chlorid were applied, slightly greater yields were obtained with the potassium chlorid, which, however, supplied about one-third more potassium than the kainit. On the other hand, either material furnished more potassium than was required by the crops produced.

TABLE 11.—MANITO FIELD: DEEP PEAT
Corn Yields—Bushels

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905	Four crops
1	None	10.9	8.1	None	17.0	12.0	48.0
2	None	10.4	10.4	Limestone, 4000 lbs	12.0	10.1	42.9
3	Kainit, 600 lbs	30.4	32.4	Limestone, 4000 lbs; Kainit, 1200 lbs	49.6	47.3	159.7
4	Kainit, 600 lbs; Acidulat'd bone, 350 lbs.	30.3	33.3	Kainit, 1200 lbs; Steamed bone, 395 lbs.	53.5	47.6	164.7
5	Potassium chlorid, 200 lbs	31.2	33.9	Potassium chlorid 400 lbs	48.5	52.7	166.3
6	Sodium chlorid, 700 lbs	11.1	13.1	None	24.0	22.1	70.3
7	Sodium chlorid, 700 lbs	13.3	14.5	Kainit, 1200 lbs	44.5	47.3	......
8	Kainit, 600 lbs	36.8	37.7	Kainit, 600 lbs	44.0	46.0	164.5
9	Kainit, 300 lbs	26.4	25.1	Kainit, 300 lbs	41.5	32.9	125.9
10	None	14.9[1]	14.9	None	26.0	13.6	69.4

[1]Estimated from 1903; no yield was taken in 1902 because of a misunderstanding.

The use of 700 pounds of sodium chlorid (common salt) produced no appreciable increase over the best untreated plots, indicating that where potassium is itself actually deficient, salts of other elements cannot take its place.

Applications of 2 tons per acre of ground limestone produced no increase in the corn crops, either when applied alone or in combination with kainit, either the first year or the second.

Reducing the application of kainit from 600 to 300 pounds for each two-year period reduced the yield of corn from 164.5 to 125.9 bushels. The two applications of 300 pounds of kainit (Plot 9) furnished 60 pounds of potassium for the four years, an amount sufficient for 84 bushels of corn (grain and stalks). Attention is called to the fact that this is practically the difference between the yield of Plot 9 (125.9 bushels) and the yield obtained from Plot 2 (42.9 bushels), the poorest untreated plot.

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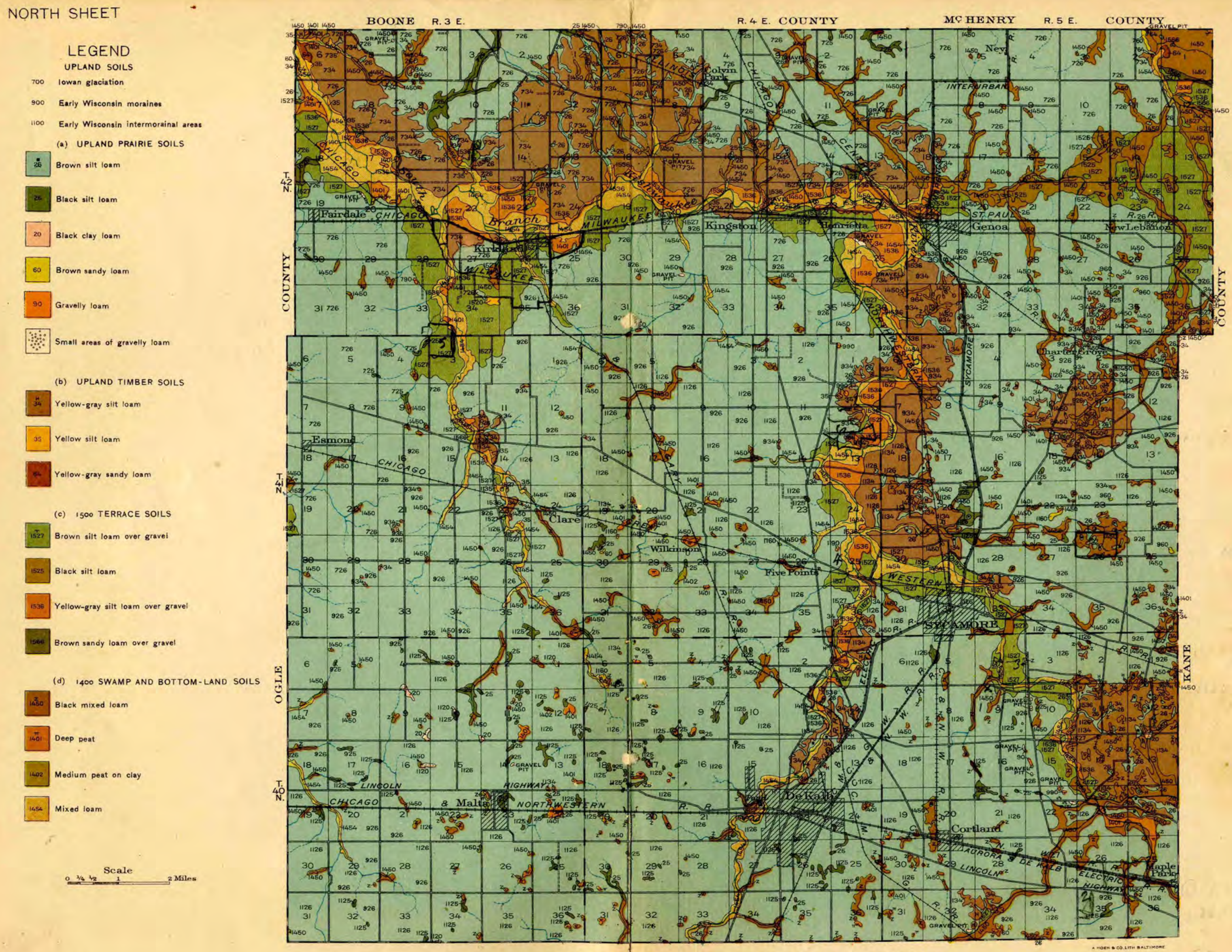

SOIL SURVEY MAP OF DE KALB COUNTY

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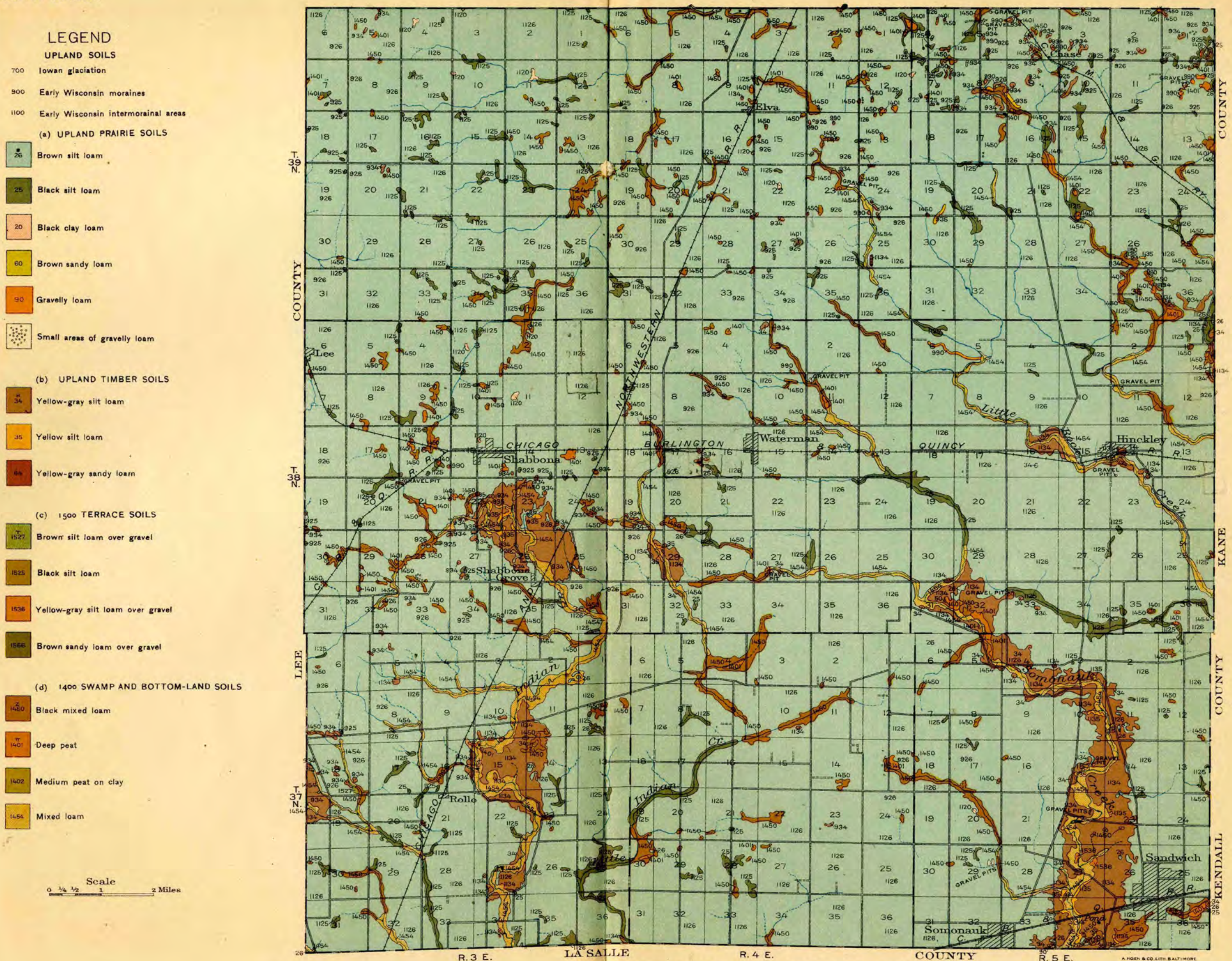

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