UNIVERSITY OF ILLINOIS

# Agricultural Experiment Station

SOIL REPORT No. 25

# LIVINGSTON COUNTY SOILS

By J. G. Mosier, S. V. Holt, F. A. Fisher, E. E. De Turk, and H. J. Snider

Prepared for publication by L. H. Smith

URBANA, ILLINOIS, JUNE, 1923

**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.

## CONTENTS OF SOIL REPORT No. 25

## LIVINGSTON COUNTY SOILS



## APPENDIX



## SUPPLEMENT

# LIVINGSTON COUNTY SOILS

By J. G. MOSIER, S. V. HOLT, F. A. FISHER, E. E. DE TURK, AND H. J. SNIDER
PREPARED FOR PUBLICATION BY L. H. SMITH[1]

## LOCATION AND CLIMATE OF LIVINGSTON COUNTY

Livingston county is located in the northeast quarter of Illinois. Its north boundary lies 102 miles south of the Wisconsin state line, and its east boundary 39 miles west of the Indiana line. The county is made up of 28½ townships, embracing an area of a little more than 1,000 square miles. It lies entirely within the geological area known as the early Wisconsin glaciation. Practically all the land is tillable and over 90 percent of the soil is of prairie formation.

The climate of Livingston county is characterized by a wide range between the extremes of winter and summer. The greatest range of any year from 1887 to 1920 was 136 degrees, in 1887. The lowest temperature recorded was –26°; the highest, 110°. The average date of the last killing frost in spring is May 1; the earliest in fall, October 13. The length of the growing season therefore is about 164 days.

The average annual precipitation for the county from 1887 to 1920 was 32.18 inches. The average rainfall by months for this period was as follows: January, 2.22 inches; February, 1.73; March, 2.64; April, 3.28; May, 3.85; June, 3.34; July, 2.88; August, 2.82; September, 3.36; October, 2.11; November, 2.14; December, 1.81. The proportion of total rainfall occurring during each season was: winter, 17.9 percent; spring, 30.4 percent; summer, 28.1 percent; autumn, 23.6 percent.

## AGRICULTURAL PRODUCTION

Livingston county is to be regarded as distinctly agricultural, with almost the entire county tillable land. In 1920, as shown by the Fourteenth Census of the United States, there were 3,726 farms, these farms having an average of 170.9 acres each, 165.5 acres of which were improved. Of these farms, 65.6 percent were operated by tenants, which was a decrease in tenantry of 6.5 percent in ten years and 14.4 percent in the last twenty years. According to this report, the average value of land is $312.79 per acre, it ranking among the first five counties of the state in this respect.

The principal crops are corn, oats, wheat, pasture, hay, and clover. Small amounts of rye, barley, and potatoes are grown. The Census reports the following as the acreage and yield of the more important 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 (Professor Mosier died November 10, 1922, after partially preparing this report); S. V. Holt and F. A. Fisher, in charge of field party; E. E. De Turk, in charge of soil analysis; H. J. Snider, in charge of experiment fields; L. H. Smith, in charge of publications.

| *Crops* | *Acreage* | *Production* |
|---|---|---|
| Corn | 258,890 | 10,079,598 bu. |
| Oats | 206,029 | 6,492,160 bu. |
| Wheat | 25,084 | 422,657 bu. |
| Timothy | 6,108 | 6,198 tons |
| Timothy and clover mixed | 7,187 | 8,676 tons |
| Clover alone | 10,015 | 11,349 tons |
| Alfalfa | 1,505 | 3,592 tons |
| Silage crops | 2,411 | 19,264 tons |
| Corn for forage | 1,696 | 3,760 tons |

The acreage of pasture is not given by the Census, but from other data it is found to be approximately 100,000. Within the past few years the soybean has been introduced, and this crop is gradually becoming established as one of the staple crops of the region. Likewise, the great value of sweet clover has recently become recognized, and it is rapidly taking its place among the more important crops of the county.

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 | 30,196 | $3,195,405 |
| Mules | 1,870 | 237,229 |
| Beef cattle | 13,655 | 991,359 |
| Dairy cattle | 26,946 | 1,703,367 |
| Sheep | 7,115 | 95,418 |
| Swine | 53,542 | 1,165,914 |
| Poultry | 466,533 | 470,628 |
| Eggs and chickens | ..... | 1,120,361 |
| Dairy products | ..... | 808,347 |

The report gives the total value of the live stock as more than 10½ million dollars.

Fruit growing is of very little importance in this county. About 32,000 quarts of small fruits were produced in 1919. The total production of apples, pears, peaches, and cherries amounted to about 4,800 bushels, and the total crop of grapes was approximately 91,000 pounds.

## SOIL FORMATION

The most important period in the geological history of the county from the standpoint of soil formation was the Glacial period, during which the material that later formed the soils was being deposited. At that time, snow and ice accumulated in the region of Labrador and to the west of Hudson Bay to such an amount that the mass pushed outward from these centers, chiefly southward, until a point was reached where the ice melted as rapidly as it advanced. In moving across the country from the far north, the ice gathered up all sorts and sizes of material, including clay, silt, sand, gravel, boulders, and even immense masses of rock. Some of these materials were carried for hundreds of miles and rubbed against surface rocks and against each other until largely ground into powder. When, thru the melting of the ice, the limit of advance was reached, the material carried by the glacier accumulated in a broad, undulating ridge or moraine. When 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 area previously covered.

During the Glacial period at least six distinct ice advances occurred that were separated by long periods of time. They are described as follows, in the order of their occurrence:

(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 exact area, however, being difficult to determine because of the effect of the subsequent glaciations; (5) the early Wisconsin, which covered the northeastern 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.

The material transported by the glacier varied with the character of the rocks over which it passed. Granites, sandstones, limestones, shales, etc., were torn from their lodging places by the enormous denuding power of the ice sheet and ground up together. A pressure of forty pounds per square inch is exerted by a mass of ice one hundred feet thick, and these ice sheets were hundreds or possibly thousands of feet in thickness. The material 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 average depth of this deposit over the state of Illinois is estimated as 115 feet.

Previous to the ice invasion, this region generally was not well suited to agriculture because of its rough and hilly character, as is shown by borings which indicate many preglacial valleys that later were filled with drift. The general effect of the glaciers was to change the surface from hilly to gently undulating. Only a few streams have done anything to change the topography, and these in only very limited areas. Most of the streams formerly flowed in broad, swampy sloughs rather than in distinct valleys.

## THE GLACIATIONS OF LIVINGSTON COUNTY

Livingston county was entirely covered by the Illinoisan glacier, which partially leveled the region by rubbing down the hills and filling the valleys. The county was covered by a deposit of boulder clay. This glacier receded, and a long period elapsed, during which a soil was formed from the glacial material that had been deposited. This is the Sangamon soil and it is found only in deep borings, as when drilling wells. The Iowan glacier followed, but so far as is known, it did not touch this county. The early Wisconsin glacier came next, and covered the Illinoisan drift, building up three moraines.

The first or oldest moraine is the Minonk ridge, which is a part of the Bloomington morainic system. This ridge is from one to three miles wide and crosses the southwest part of the county (see drainage map). The next moraine to be formed was the Cayuga-Chatsworth ridge, which is really one moraine, tho it is sometimes spoken of as two. It is not very distinct and is broken thru by the Vermilion river. It divides into two ridges for a short distance in the south part of the county in Township 25 North, Range 8 East, but unites again in Ford county. The largest and most important moraine of the county is the Marseilles, which enters the county in Township 30 North, Range 5 East, swings to the southeast and east and leaves the county in Township 29 North, Range 8 East. This ridge is from eight to ten miles wide and rises 75 to 100 feet above the land at the outer margin of the Cayuga-Chatworth moraine. It was pushed against the Cayuga moraine where for some distance the two moraines apparently form a single ridge.

The glacial drift is very much like that of other counties in this region. It consists of blue boulder clay containing beds or pockets of gravel and sand which form the source of the water supply. Altho rock outcrops occur along the Vermilion river, the average thickness of the drift is nearly 150 feet. The greatest depth of drift found thus far is in the south part of the town of Odell, where it is 360 feet deep. Three and one-half miles southwest of Odell the drift is 300 feet deep. Leverett, who has studied extensively the geology of this region, says, "There appear to be buried valleys traversing the county whose rock floors are 150 to 200 feet below the general level of the rock surface. In such valleys the drift is 300 feet in thickness."

### THE ACTION OF WIND AND WATER

The deposit of glacial drift does not form the material of the present soil except in small areas. The rock flour produced by the grinding action of the glaciers has been reworked by the wind and deposited over practically all of the county to a depth of 12 to 40 inches. This wind-blown, or loessial, material now covering the level and less rolling areas, has been transformed into soil by weathering and the accumulation of organic matter. There is little doubt but that this wind-blown material was at one time 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.

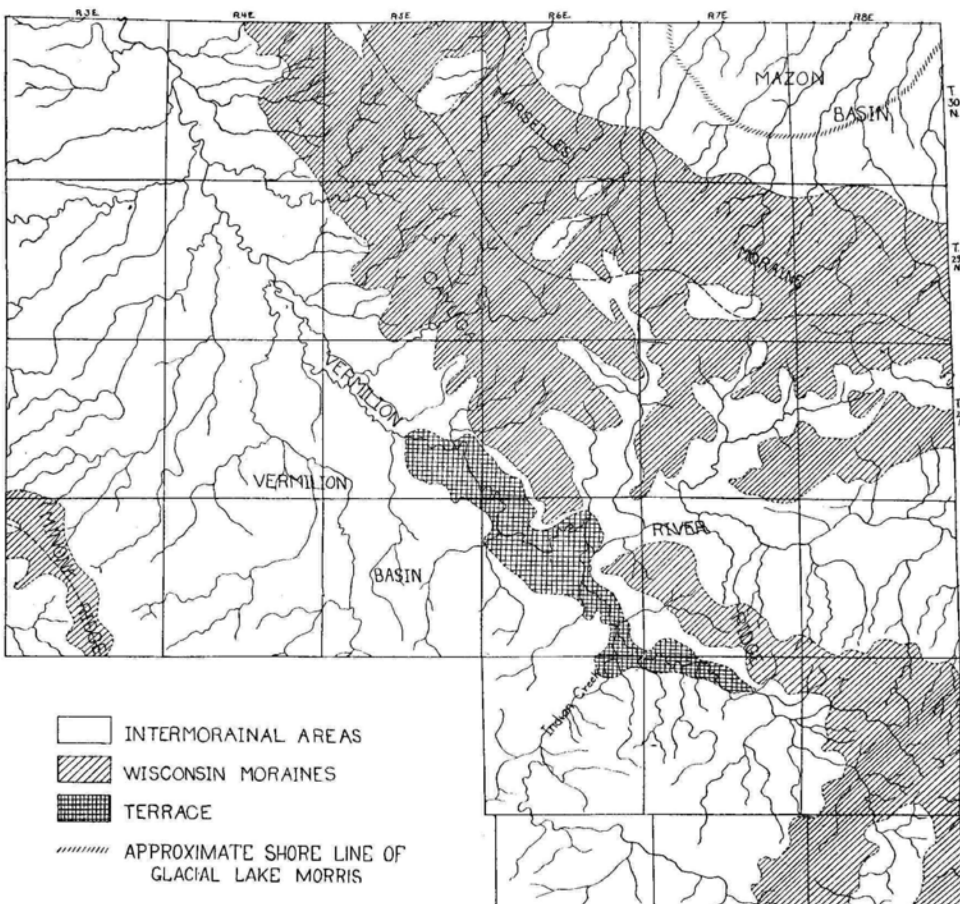
During the melting of the glacier the streams draining this area were frequently flooded, moving large amounts of rather coarse material, such as sand and gravel. This was deposited in the valleys, partly filling them. Later the streams cut down thru the fill, leaving gravel terraces. This gravel was afterward covered with the fine material that now constitutes the soil. These terraces occur principally along the Vermilion river. During the melting of the late Wisconsin glacier in northern Indiana and southern Michigan, some of the flood waters came westward across Iroquois, Ford, and Livingston counties, finding their way into the Vermilion river and thence into the Illinois. These floods formed the broad terraces in Townships 27 and 28 North, Ranges 5 and 6 East. The terrace area ends at the rock ridge which is exposed in the bottom of the river in Section 21, northwest of Pontiac.

A large glacial lake, known as Glacial Lake Morris, which formerly covered a very large part of Grundy county and extended south into the northeastern part of Livingston county in Township 30 North, Ranges 7 and 8 East, was responsible for the deposition of the large amount of black clay loam in that region.

## PHYSIOGRAPHY AND DRAINAGE

In general Livingston county varies in topography from flat to rolling. There is no large amount of hilly land in the county, and the small area that does exist is found as bluffs along the bottom land of the Vermilion river. The variations in topography are due to three causes—the action of streams, of glaciers, and of wind. The latter, so far as it has modified topography, has been of no consequence except in the region north of Pontiac, where a few low sand dunes have been produced by the wind.

All the land of the county drains into the Illinois river, but thru various streams. The northeastern part, comprizing about eight townships, is drained by tributaries of the Mazon river; about twelve sections in the southwest corner have their outlet thru the Mackinaw river; while the remainder of the county, which forms a broad, flat valley, is drained by the Vermilion




MAP SHOWING THE DRAINAGE BASINS OF LIVINGSTON COUNTY WITH MORAINAL, INTERMORAINAL, AND TERRACE AREAS river. Formerly, much of the county was swampy, and contained many ponds that rarely became dry. The extent of these areas is indicated generally by the amount of black clay loam. This district, with the aid of dredge ditches to furnish the outlets, has been thoroly tile-drained and now constitutes excellent agricultural land. The crest of the Marseilles moraine forms the divide between the Mazon river and the Vermilion river. The Minonk ridge is the divide between the Vermilion and Mackinaw rivers.

The altitude of Livingston county varies from 831 feet to less than 600. The following figures give the altitudes of certain places in the county. Ancona, 630 feet; Blackstone, 738; Budd, 705; Campus, 653; Cayuga, 691; Charlotte, 668; Chatsworth, 736; Cornell, 629; Dwight, 641; Emington, 701; Eylar, 698; Fairbury, 686; Flanagan, 676; Forrest, 688; Graymont, 657; Healey, 718; Lodemia, 658; Long Point, 641; Manville, 617; McDowell, 652; Missal, 668; Nevada, 680; Odell, 721; Pontiac, 647; Risk, 747; Rowe, 642; Saunemin, 686; Saxony, 696; Scovel, 694; Smithdale, 624; Strawn, 768; Sunbury, 660; Swygert, 737; Wilson, 615; Wing, 658. The altitude of the Marseilles moraine is from 740 to 755 feet. The highest point in the county, which is 831 feet, lies in the Cayuga ridge, in Section 5, Township 25 North, Range 8 East.

## SOIL TYPES

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

(a) *Upland Prairie Soils,* including the upland soils that have not been covered with forests, at least for any great length of time, 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.

(e) *Residual Soils,* including rock outcrop areas, and soils formed in place thru weathering of rocks.

Table 1 gives a list of the soil types found in Livingston county, the area of each type in square miles and in acres, and also its percentage of the total area. For example, we learn from the table that brown silt loam occupies about 775 square miles, or a little more than 496,000 acres, and that this type constitutes practically 75 percent of the total area 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 to this report.

TABLE 1.—SOIL TYPES OF LIVINGSTON COUNTY, ILLINOIS

| Soil type No. | Name of type | Area in square miles | Area in acres | Percent of total area |
|---|---|---|---|---|
| | (a) Upland Prairie Soils (900, 1100) | | | |
| −26 | Brown silt loam | 775.04 | 496,026 | 75.265 |
| −20 | Black clay loam | 163.79 | 104,826 | 15.906 |
| −60 | Brown sandy loam | 9.85 | 6,304 | .956 |
| −28.1 | Brown silt loam on tight clay | 15.74 | 10,074 | 1.529 |
| −20.2 | Gravelly black clay loam | .32 | 205 | .031 |
| −28 | Brown-gray silt loam on tight clay | 1.01 | 646 | .099 |
| −26.4 | Brown silt loam on gravel | .27 | 173 | .026 |
| −26.5 | Brown silt loam on rock | .14 | 89 | .013 |
| | | 966.16 | 618,343 | 93.825 |
| | (b) Upland Timber Soils (900, 1100) | | | |
| −34 | Yellow-gray silt loam | 18.92 | 12,109 | 1.838 |
| −35 | Yellow silt loam | 2.07 | 1,325 | .202 |
| −64 | Yellow-gray sandy loam | .22 | 141 | .021 |
| | | 21.21 | 13,575 | 2.061 |
| | (c) Terrace Soils (1500) | | | |
| −27 | Brown silt loam over gravel | 13.39 | 8,570 | 1.300 |
| −66 | Brown sandy loam over gravel | 2.27 | 1,453 | .220 |
| −20 | Black clay loam | 1.27 | 813 | .123 |
| −36 | Yellow-gray silt loam over gravel | 1.87 | 1,197 | .181 |
| −26.4 | Brown silt loam on gravel | .59 | 378 | .057 |
| −61 | Black sandy loam | .05 | 32 | .005 |
| −67 | Yellow-gray sandy loam over gravel | .26 | 166 | .026 |
| −28 | Brown-gray silt loam on tight clay | .14 | 89 | .013 |
| −68 | Brown-gray sandy loam on tight clay | .07 | 45 | .007 |
| | | 19.91 | 12,743 | 1.932 |
| | (d) Late Swamp and Bottom-Land Soils (1400) | | | |
| −54 | Mixed loam | 20.96 | 13,414 | 2.036 |
| −26 | Deep brown silt loam | .50 | 320 | .048 |
| −01 | Deep peat | .88 | 563 | .085 |
| −02 | Medium peat on clay | .05 | 32 | .005 |
| −13.6 | Muck on marl | .01 | 6 | .001 |
| | | 22.40 | 14,335 | 2.175 |
| | (e) Residual Soil (000) | | | |
| −98 | Stony loam | .02 | 13 | .002 |
| | (f) Miscellaneous | | | |
| | Rock quarries and gravel pits | .05 | 32 | .005 |
| | Total | 1,029.75 | 659,041 | 100.000 |

## INVOICE OF PLANT FOOD IN LIVINGSTON 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 33), 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 Livingston 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 35 and 36 of the Appendix.

The variation among the different types of soil of Livingston 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, more than fifteen times as much nitrogen as 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 nearly five times as much potassium as is found in the deep peat. The supply of phosphorus in the surface soil varies from 640 pounds per acre in the yellow-gray sandy loam over gravel to 2,010 pounds in the deep peat. A sulfur content of only 200 pounds per acre is found in the yellow-gray sandy loam over gravel, while in an equal volume of deep peat the analysis shows 2,500 pounds of this element. The magnesium varies in the different types from less than 3,000 to more than 16,000 pounds, and the calcium content ranges from 3,500 to nearly 40,000 pounds per acre.

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 Livingston county, the brown silt

TABLE 2.—PLANT FOOD IN THE SOILS OF LIVINGSTON 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 (900, 1100) | | | | | | | |
| 926<br>1126 | Brown silt loam.......... | 63 770 | 5 130 | 1 050 | 1 000 | 38 010 | 9 590 | 10 840 |
| 1120 | Black clay loam.......... | 64 100 | 5 790 | 1 470 | 1 100 | 39 730 | 16 090 | 20 270 |
| 1160 | Brown sandy loam......... | 40 400 | 3 330 | 650 | 780 | 27 500 | 4 630 | 6 680 |
| 928.1<br>1128.1 | Brown silt loam on tight clay | 55 690 | 4 730 | 1 080 | 950 | 41 870 | 11 490 | 9 740 |
| 1120.2 | Gravelly black clay loam... | 87 120 | 7 960 | 1 780 | 1 640 | 29 160 | 12 880 | 22 660 |
| 1128 | Brown-gray silt loam on tight clay.............. | 44 160 | 3 700 | 1 020 | 720 | 45 580 | 9 180 | 11 240 |
| 1126.4 | Brown silt loam on gravel.. | 44 060 | 3 740 | 1 060 | 860 | 35 380 | 8 260 | 8 440 |
| 1126.5 | Brown silt loam on rock.... | 48 380 | 4 620 | 1 260 | 300 | 28 720 | 6 580 | 10 400 |
| | (b) Upland Timber Soils (900, 1100) | | | | | | | |
| 1134 | Yellow-gray silt loam...... | 36 740 | 3 310 | 1 200 | 850 | 38 120 | 6 480 | 8 910 |
| 1135 | Yellow silt loam........... | 20 620 | 1 900 | 1 100 | 600 | 38 920 | 5 960 | 8 260 |
| 1164 | Yellow-gray sandy loam.... | 23 280 | 1 740 | 840 | 660 | 28 180 | 4 060 | 6 140 |
| | (c) Terrace Soils (1500) | | | | | | | |
| 1527 | Brown silt loam over gravel | 33 940 | 3 000 | 880 | 640 | 33 120 | 5 920 | 7 360 |
| 1566 | Brown sandy loam over gravel................ | 42 540 | 3 900 | 1 040 | 900 | 32 540 | 5 960 | 8 100 |
| 1520 | Black clay loam.......... | See figures for upland black clay loam (1120) | | | | | | |
| 1536 | Yellow-gray silt loam over gravel................ | 43 990 | 4 310 | 1 380 | 760 | 34 200 | 5 080 | 9 970 |
| 1526.4 | Brown silt loam on gravel.. | 34 940 | 3 280 | 960 | 940 | 35 120 | 8 380 | 9 080 |
| 1561 | Black sandy loam......... | 73 500 | 6 300 | 1 520 | 1 200 | 29 760 | 9 000 | 15 660 |
| 1567 | Yellow-gray sandy loam over gravel............ | 29 320 | 2 520 | 640 | 200 | 39 240 | 2 880 | 5 980 |
| 1528 | Brown-gray silt loam on tight clay.............. | 70 380 | 6 980 | 1 300 | 640 | 38 720 | 5 300 | 11 700 |
| 1568 | Brown-gray sandy loam on tight clay.............. | 43 600 | 3 420 | 740 | 720 | 25 260 | 4 120 | 8 660 |
| | (d) Late Swamp and Bottom-Land Soils (1400) | | | | | | | |
| 1454 | Mixed loam[1]............ | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 1426 | Deep brown silt loam...... | 85 300 | 6 820 | 1 540 | 1 340 | 46 140 | 13 700 | 16 860 |
| 1401 | Deep peat[2]............... | 301 870 | 27 040 | 2 010 | 2 500 | 8 290 | 5 520 | 39 790 |
| 1402 | Medium peat on clay[2]..... | 161 290 | 13 890 | 1 380 | 2 220 | 15 690 | 7 180 | 17 800 |
| 1413.6 | Muck on marl[3]........... | 197 900 | 16 460 | 1 040 | 1 740 | 2 280 | 9 590 | 2 630 |
| | (e) Residual Soils (000) | | | | | | | |
| 098 | Stony loam............... | | | | | | | |

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures for 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 35 and 36.

[1]On account of the heterogeneous character of mixed loam, chemical analyses are not included for this type.

[2]These amounts are based upon the assumption that the surface stratum contains 1 million pounds of soil, an estimate which is, of course, very crude.

[3]Based on an estimate of 1½ million pounds of soil per acre.

TABLE 3.—PLANT FOOD IN THE SOILS OF LIVINGSTON 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 (900, 1100) | | | | | | | |
| 926, 1126 | Brown silt loam | 74 710 | 6 480 | 1 580 | 1 380 | 78 900 | 25 770 | 19 510 |
| 1120 | Black clay loam | 67 730 | 6 380 | 2 350 | 1 300 | 81 190 | 34 640 | 38 540 |
| 1160 | Brown sandy loam | 47 980 | 4 340 | 1 120 | 1 280 | 55 220 | 12 390 | 18 100 |
| 928.1, 1128.1 | Brown silt loam on tight clay | 44 330 | 4 970 | 1 310 | 1 350 | 91 310 | 37 610 | 16 970 |
| 1120.2 | Gravelly black clay loam | 78 360 | 6 720 | 2 560 | 1 680 | 63 680 | 26 320 | 38 800 |
| 1128 | Brown-gray silt loam on tight clay | 35 840 | 3 920 | 1 560 | 640 | 100 280 | 28 560 | 20 280 |
| 1126.4 | Brown silt loam on gravel | 59 200 | 5 560 | 1 880 | 1 160 | 70 600 | 19 840 | 15 480 |
| 1126.5 | Brown silt loam on rock | 63 160 | 6 520 | 2 040 | 480 | 56 760 | 17 640 | 25 840 |
| | (b) Upland Timber Soils (900, 1100) | | | | | | | |
| 1134 | Yellow-gray silt loam | 21 920 | 2 700 | 1 820 | 1 060 | 80 680 | 19 580 | 15 280 |
| 1135 | Yellow silt loam | 18 560 | 1 920 | 2 000 | 400 | 81 160 | 19 960 | 16 680 |
| 1164 | Yellow-gray sandy loam | 11 080 | 1 080 | 1 480 | 720 | 56 600 | 7 920 | 9 440 |
| | (c) Terrace Soils (1500) | | | | | | | |
| 1527 | Brown silt loam over gravel | 57 560 | 5 160 | 1 720 | 1 080 | 68 560 | 15 120 | 16 720 |
| 1566 | Brown sandy loam over gravel | 61 440 | 5 880 | 1 800 | 1 480 | 66 120 | 13 960 | 15 320 |
| 1520 | Black clay loam | See figures for upland black clay loam (1120) | | | | | | |
| 1536 | Yellow-gray silt loam over gravel | 32 300 | 4 060 | 1 900 | 780 | 69 820 | 13 120 | 16 420 |
| 1526.4 | Brown silt loam on gravel | 55 200 | 5 960 | 1 680 | 1 640 | 71 120 | 20 560 | 17 520 |
| 1561 | Black sandy loam | 70 800 | 5 920 | 2 240 | 1 960 | 59 840 | 17 400 | 24 320 |
| 1567 | Yellow-gray sandy loam over gravel | 18 720 | 2 400 | 1 200 | 680 | 62 840 | 9 720 | 12 720 |
| 1528 | Brown-gray silt loam on tight clay | 31 040 | 3 520 | 2 040 | 760 | 81 760 | 13 000 | 19 980 |
| 1568 | Brown-gray sandy loam on tight clay | 30 240 | 3 360 | 1 120 | 520 | 53 280 | 7 160 | 13 760 |
| | (d) Late Swamp and Bottom-Land Soils (1400) | | | | | | | |
| 1454 | Mixed loam[1] | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 1426 | Deep brown silt loam | 95 040 | 8 920 | 2 040 | 1 520 | 89 320 | 31 600 | 24 120 |
| 1401 | Deep peat[2] | 742 540 | 56 840 | 3 060 | 51 960 | 10 340 | 9 860 | 61 560 |
| 1402 | Medium peat on clay[2] | 285 920 | 24 420 | 1 840 | 5 760 | 32 020 | 16 520 | 36 860 |
| 1413.6 | Muck on marl | 117 240 | 9 560 | 1 840 | 3 320 | 65 160 | 40 200 | 85 560 |
| | (e) Residual Soils (000) | | | | | | | |
| 098 | Stony loam | | | | | | | |

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

[1]On account of the heterogeneous character of mixed loam, chemical analyses are not included for this type.
[2]Amounts reported are for 2 million pounds of deep peat and medium peat.

loam, contains only enough total nitrogen in the plowed soil, that is, in the surface stratum, 0 to 6⅔ inches, for the production of such yields to supply about ten rotations.

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 fourteen crop rotations yielding at the rates suggested above. On the other

TABLE 4.—PLANT FOOD IN THE SOILS OF LIVINGSTON 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 (900, 1100) | | | | | | | |
| 926, 1126 | Brown silt loam | 31 830 | 3 770 | 2 050 | 1 450 | 139 120 | 80 270 | 105 870 |
| 1120 | Black clay loam | 30 910 | 3 630 | 3 070 | 1 050 | 131 540 | 75 270 | 96 570 |
| 1160 | Brown sandy loam | 26 100 | 2 490 | 1 080 | 1 290 | 82 440 | 19 080 | 18 990 |
| 928.1, 1128.1 | Brown silt loam on tight clay | 22 820 | 3 800 | 2 100 | 2 250[1] | 170 400 | 93 580 | 85 680 |
| 1120.2 | Gravelly black clay loam | 42 600 | 4 020 | 2 700 | 1 260 | 91 260 | 42 120 | 57 900 |
| 1128 | Brown-gray silt loam on tight clay | 24 240 | 3 360 | 2 640 | 1 020 | 157 080 | 61 920 | 40 200 |
| 1126.4 | Brown silt loam on gravel | 29 400 | 3 600 | 2 100 | 1 260 | 110 220 | 54 420 | 75 960 |
| | (b) Upland Timber Soils (900, 1100) | | | | | | | |
| 1134 | Yellow-gray silt loam | 19 710 | 3 150 | 3 420 | 1 140 | 145 740 | 49 950 | 23 340 |
| 1135 | Yellow silt loam | 20 460 | 2 220 | 3 240 | 300 | 107 640 | 109 200 | 170 400 |
| 1164 | Yellow-gray sandy loam | 15 060 | 1 320 | 2 400 | 1 620 | 89 940 | 18 180 | 14 160 |
| | (c) Terrace Soils (1500) | | | | | | | |
| 1527 | Brown silt loam over gravel | 35 820 | 4 320 | 2 160 | 1 020 | 103 740 | 34 500 | 23 340 |
| 1566 | Brown sandy loam over gravel | 28 740 | 3 840 | 2 040 | 1 740 | 94 020 | 25 440 | 22 620 |
| 1520 | Black clay loam | See figures for upland black clay loam (1120) | | | | | | |
| 1536 | Yellow-gray silt loam over gravel | 18 270 | 3 870 | 3 240 | 1 020 | 99 720 | 29 100 | 26 220 |
| 1526.4 | Brown silt loam on gravel | 52 500 | 6 180 | 2 640 | 1 260 | 114 300 | 38 340 | 26 640 |
| 1561 | Black sandy loam | 27 360 | 3 240 | 2 520 | 1 860 | 91 020 | 26 880 | 35 700 |
| 1567 | Yellow-gray sandy loam over gravel | 9 840 | 2 220 | 2 220 | 480 | 86 340 | 23 700 | 13 940 |
| 1528 | Brown-gray silt loam on tight clay | 24 360 | 4 260 | 3 240 | 1 260 | 122 520 | 29 340 | 28 800 |
| 1568 | Brown-gray sandy loam on tight clay | 19 980 | 2 760 | 1 380 | 540 | 83 160 | 29 700 | 20 160 |
| | (d) Late Swamp and Bottom-Land Soils (1400) | | | | | | | |
| 1454 | Mixed loam[2] | ....... | ....... | ....... | ....... | ....... | ....... | ....... |
| 1426 | Deep brown silt loam | 62 100 | 6 420 | 2 280 | 1 020 | 147 000 | 48 480 | 28 620 |
| 1401 | Deep peat[3] | 889 800 | 69 600 | 2 820 | 153 570 | 14 220 | 19 050 | 154 350 |
| 1402 | Medium peat on clay[4] | 457 710 | 34 410 | 1 620 | 13 680 | 42 810 | 25 560 | 52 470 |
| 1413.6 | Muck on marl | 70 500 | 4 140 | 2 700 | 3 780 | 95 520 | 90 540 | 588 480 |
| | (e) Residual Soils (000) | | | | | | | |
| 098 | Stony loam | | | | | | | |

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

[1]One sample contained 51,780 pounds of sulfur per acre, which figure is excluded from the average for the type. See explanation on page 18.

[2]On account of the heterogeneous character of mixed loam, chemical analyses are not included for this type.

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

[4]Amounts reported are for 3 million pounds, the same as for deep peat. For explanation see page 27.

hand the amount of potassium in the surface layer of this common soil type is equivalent to that which would be used in 472 years of such cropping provided the total crops were to be removed from the land; or, in case only the grain were removed, this amount of potassium would supply such crops for about 30 centuries.

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.

## DESCRIPTION OF INDIVIDUAL SOIL TYPES

### (a) UPLAND PRAIRIE SOILS

The upland prairie soils of Livingston county cover 966.16 square miles, or 93.8 percent of the area of the county. They usually occupy the less eroded areas of the upland. They are black or brown in color owing to their high organic-matter content. This land was originally covered with prairie grasses, the partially decayed roots of which have been the main source of the organic matter. The flat, poorly drained areas contain the greater amounts of organic matter owing to the more luxuriant growth of the grasses that grew on such areas and to the excessive moisture in the soil which provided conditions better adapted for the preservation of their roots.

### Brown Silt Loam (926, 1126)

Brown silt loam is the most extensive type in Livingston county. It covers an area of 775.04 square miles, or practically 75 percent of the area of the county. In topography it varies from flat to slightly rolling. The more rolling phase is found in the northeast part of the county and on the Marseilles moraine.

While the brown silt loam is primarily a prairie type, timber has recently invaded it to a slight extent in some localities. The trees found on the timbered brown silt loam are usually bur oak, wild cherry, black walnut, ash, and elm, but their occupation of the soil has not been sufficiently long to change its character to any great extent.

In general the various strata of this type are formed from wind-blown loessial material, from boulder clay, or from material deposited in shallow water. A peculiar phase of the brown silt loam in this county is found on the moraines, where as a consequence of the removal of part of the fine loessial material the glacial drift is encountered at less than 30 inches from the surface; sometimes it even outcrops. On the steeper parts of the moraines erosion has taken place to such an extent that the brown soil is nearly all washed away and these areas, if of sufficient size, are mapped as a different type, such as yellow silt loam (–35) if very steep, or yellow-gray silt loam (—34) if not so steep. Many such areas are too small to be represented on the map. In general the brown silt loam of the moraines (926), containing as it does less organic matter than the average, is affected to some extent by the tighter subsoil formed by the glacial drift. If the drift is rather compact, as is occasionally the case, the subsoil is somewhat inferior, owing to interference with drainage. This condition is indicated by a grayish color appearing after the soil becomes dry following a rain. Fortunately, however, this condition does not occur very frequently nor does it include large areas, since most of the glacial drift is pervious and some is even gravelly.

Large areas of the county were at one time covered by temporary lakes. In these lakes a deposit of rather fine-grained clay was made which was later covered by ordinary soil material. In this way a rather heavy subsoil was formed somewhat to the detriment of the drainage. This heavy phase merges into the condition represented by the type mapped as brown silt loam on tight clay (—28.1), a typical area of which occurs on Cayuga ridge.

*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 55 to 75 percent of the different grades of silt. In the lower areas the proportion of clay is usually higher than on the more rolling parts, where a perceptible amount of sand may occur. With the flooding of some parts of the county during the time of the melting of the glacier, more or less sand was carried in and deposited on the shores of the flooded parts. Some of this sand was later carried to the higher lands by the wind and became mixed with the soil, forming a sandy loam or a sandy phase of the silt loam.

The organic-matter content of the surface soil varies from 4 to 7 percent, depending on topography, and averages about 5.4 percent, or 54 tons per acre. In small areas on the more rolling parts of the moraines erosion has occurred to such an extent that the organic matter is rather low.

*The natural subsurface* is represented by a stratum which varies from 4 to 18 inches in thickness. This variation is due either to erosion, or to the fact that shallower-rooting grasses usually grew on the higher and better drained land, or perhaps to both of these causes. Erosion has removed some of the surface soil from the steeper parts and deposited it on the lower land, thus leaving a thinner layer of the dark soil in one case and producing a thicker one in the other. The physical composition of the subsurface varies in somewhat the same manner as the surface soil. In some parts, especially on the moraines, glacial till constitutes a part or all of the subsurface. The organic-matter content of the subsurface (6⅔ to 20 inches) is about 3.1 percent, or 62 tons per acre. In color this stratum varies from a dark brown or almost black to a yellowish brown, always changing to a lighter color with increasing depth.

*The natural subsoil* begins at a depth of 12 to 22 inches and extends to an indefinite depth. It varies from a yellow to a drabbish yellow, silty, clayey material, sometimes composed partially or even wholly of boulder clay. In the flat areas, however, not subject to erosion but where material has been washed in from the higher surrounding land, the subsoil to a depth of 40 inches may not reach the boulder clay. The average depth to till is about 36 inches.

*Management.*—When the virgin brown silt loam was first cropped it was in fine tilth, it worked easily, and large crops could be grown with much less work than now. Continuous cropping to corn or to corn and oats, with the burning of corn stalks, stubble, grass, and even straw in many cases, has in a great measure destroyed the tilth, so that the soil becomes more difficult to work, washes badly, runs together, and bakes more readily than formerly. Unless the moisture conditions are very favorable, the ground will plow up cloddy, with the result that unless well-distributed rains follow, a good seed bed is difficult to produce. The clods may remain all season. Much plant-food material will be locked up in them, and the best results cannot be obtained. This condition of poor tilth may become serious if the present methods of management continue; in some cases it is already one of the factors that limit crop yields. The remedy is to use a rotation which includes a clover crop and to increase the organic-matter content by plowing under every available form of vegetable material, such as farm manure, corn stalks, straw, clover, stubble, and even weeds. Fresh organic matter is not only of great value in improving the physical condition of this type of soil, but it is also important because of its nitrogen content. Furthermore, as it decays it liberates mineral plant-food elements such as potassium, of which there is an inexhaustible supply in 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 the fall-plowed land runs together during the winter, or at any time when heavy rains occur. In the spring following fall plowing, the land should be disked early and deep for the purpose of conserving moisture, raising the temperature, and making plant food available.

On most of the brown silt loam in Livingston county, limestone is already becoming deficient in the upper strata, altho it usually exists in considerable quantity in the subsoil. If the tests for carbonates and acidity described in the Appendix, pages 35 and 36, indicate the need of limestone, or if because of lime deficiency such crops as sweet clover and alfalfa fail to grow well, an application of about 2 tons of limestone per acre is recommended.

Rock phosphate has been used on many farms in Livingston county with apparently very beneficial results. The results of the field experiments in the use of this material will be found in the Supplement. In applying rock phosphate not less than one-half ton per acre should be used as the initial application, with a half-ton for each subsequent crop rotation. Under such treatment the phosphorus content of the soil will be gradually increased so that the time will come when the applications may be discontinued for a time. At just what point the law of diminishing returns comes into effect remains for experience to determine.

Suggestions for practical systems of cropping will be found in the discussion of crop rotations in the Appendix, on page 42. For the results of actual field experiments in improving the soil of the brown silt loam type the reader is referred to pages 45 to 54 of the Supplement.

### Black Clay Loam (920, 1120)

Black clay loam represents the flat prairie land that was formerly swampy. It is sometimes called "gumbo" because of its sticky character. Its occurrence in the flat, poorly drained areas is due to the accumulation of organic matter and to the washing in of clay and fine silt from the higher areas.

Black clay loam presents many variations. It may change with a difference of only a foot or two in elevation. In this county, as elsewhere, the boundary lines between the black clay loam and the brown silt loam are not always distinct. Sometimes on the border between these two types the subsoil is distinctly that of black clay loam, while the surface soil is very silty, or is a good brown silt loam. The washing in of silty material from the surrounding higher lands, especially near the edges of the areas, modifies the character of the soil, giving it a brown silt loam surface. With the annual cultivation of the soil, this change is taking place more rapidly now than formerly when washing was largely prevented by prairie grasses. Many small areas of black clay loam in the more rolling parts are being slowly buried by this process.

This type is very widely distributed over the county, as is shown by the fact that, aside from the timber and terrace areas where this type would be expected to occur only rarely, there are but ten sections that do not have an area of black clay loam large enough to map. It occurs in areas that were formerly sloughs and ponds, and even in the small kettle-hole ponds on the moraines, altho most of these are so small that they cannot be shown on the map. There are many large areas of the type, as in Township 30 North, Ranges 7 and 8 East, Township 27 North, Range 7 East, and a strip eight or ten miles wide west of the Vermilion river. Altogether this type covers an area of 163.79 square miles, or about 16 percent of the total area of the county.

*The surface soil,* 0 to 6⅔ inches, is a black, plastic, granular, clay loam varying locally to a black clayey silt loam, or even to a black sandy clay loam which may contain gravel. These variations in physical composition occur as the type merges into other types. In some places that were formerly sloughs, the water has deposited gravel in sufficient abundance to form what is mapped as gravelly black clay loam (—20.2). Recent erosion has occasionally covered the black clay loam with several inches of dark or black, silty material, which often makes it difficult to draw the soil boundary. If erosion continues, as it undoubtedly will, the soil boundary may be changed entirely by the burying of the black clay loam with brown silt loam. The organic-matter content varies from 5.1 to 10.6 percent, with an average of 6.2 percent or 62 tons per acre. The organic matter in the kettle-hole depressions on the moraines is sometimes very high.

*The natural subsurface stratum* has a thickness of 10 to 20 inches. It varies from a black to a brownish drab clay loam and is usually somewhat heavier than the surface soil. It grades into a dull yellow or a drabbish or olive-colored material with increasing depth. The average organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 3 percent, or 60 tons per acre. The stratum is usually rather pervious to water, owing to jointing or checking from shrinkage in times of drouth, to the penetration of plant roots, and to the action of crayfish and other animals. Some exceptions to this are found where it grades toward brown-gray silt loam on tight clay (1128) and brown silt loam on tight clay (1128.1). Here the lower strata become somewhat impervious and drainage is slow.

*The subsoil* to a depth of 40 inches varies in composition from a clayey silt to a very heavy clay, and in color from a dull drabbish yellow to drab or olive. Areas of the heavier phase are found in Townships 29 and 30 North, Ranges 4 and 5 East. Because of poor natural drainage, the iron in the subsoil is not highly oxidized. Concretions of calcium carbonate are frequently found. The perviousness of the subsoil is about the same as that of the subsurface and is due to the same causes. When thrown out on the surface where wetting and drying may take place, this clayey material soon breaks into small, irregular masses about one-fourth to one-half inch square in section.

*Management.*—Drainage is the first requirement in the management of this type and, if the outlet is obtainable, this may usually be effected with little difficulty. Thoro drainage helps to keep the soil in good physical condition.

After the organic matter is necessarily destroyed by the process of nitrification, and after the limestone is removed by cropping and leaching, the physical condition of the soil becomes poorer, and as a consequence more difficult to work. Both organic matter and limestone tend to develop granulation and mellowness, which are very essential with heavy soils. The organic matter should be maintained by turning under manure and such crop residues as corn stalks and straw, and by the use of clover and pasture in rotations.

In many cases the use of limestone will probably be of little or no value on this soil because the subsoil and subsurface are naturally charged with carbonates, and in some instances even the surface soil contains carbonates. Because of exceptions to these conditions, however, it is recommended that the tests for acidity and carbonates described in the Appendix, pages 35 and 36, be made; and if carbonates are not found within a foot of the surface, a moderate application of limestone, about 2 tons per acre, should be made.

Altho the black clay loam is one of the most productive soils in the state, it has a tendency to shrink and expand to such a degree as to be objectionable at times, especially during drouth. This results in the formation of cracks, which are sometimes as much as two or more inches in width at the surface and extend with lessening width to two or three feet in depth. These cracks allow the soil to dry out rapidly, and as a result the crop is injured thru lack of moisture. They do much damage by "blocking out" hills of corn and severing the roots. While cracking may not be prevented entirely, good tilth with a soil mulch will do much toward that end. Cultivation is more essential on this type, both for aeration and for the conservation of moisture, than on almost any other type in the county. It must be remembered, however, that cultivation should be as shallow as possible in order to prevent injury to the roots of the growing crop. (See Bulletin 181.)

Occasional small patches of alkali soil are found in areas of black clay loam. These spots are indicated by the fact that oats lodge badly and corn makes a poor growth, usually turning yellow or brown. If the amount of alkali is large, the corn may not grow to a height of more than two or three feet and will have a bushy appearance. Even if it reaches almost normal height, it does not produce much grain. The fragments of shells that are frequently found are indications of alkali. A sweet clover crop turned under is probably the best remedy. Good underdrainage should be provided.

### Brown Sandy Loam (960, 1160)

The brown sandy loam of the upland is confined principally to four areas, as follows: Townships 29 and 30 North, Range 8 East; Township 28 North, Range 8 East; Township 25 North, Ranges 7 and 8 East; and Township 28 North, Range 5 East. In the formation of this type it seems probable that at one time the sand was laid down on the shore lines of old lakes and was later reworked to some extent by the wind. Other types of soil lying in proximity to the brown sandy loam contain more sand than normally occurs. The total area of brown sandy loam in the county is 9.85 square miles or 6,304 acres.

*The surface soil,* 0 to 6⅔ inches, is a brown sandy loam varying in color from light brown to black, and in physical composition from a loam with about 50 percent of sand to a very sandy loam carrying 75 percent, or slightly more, of sand. A representative sample would contain from 60 to 65 percent of sand, mostly of medium grade. Many small areas of sand are found in this type but they are too small to be shown separately on the map. The organic-matter content is about 3.2 percent, or 32 tons per acre.

*The natural subsurface stratum* varies in thickness from 7 to 12 inches, and in color from dark brown to brownish yellow, usually passing into a yellow sandy silt or silty sand in the lower part of the stratum. In physical composition it varies even more than the surface layer. The organic-matter content of the stratum sampled (6⅔ to 20 inches) is about 1.7 percent, or 34 tons per acre.

*The subsoil* varies both in color and in physical composition. The color may be a bright yellow under conditions of good drainage, or a grayish yellow where the water table has been rather high. In composition, it may be sand, sandy silt, or sandy clayey silt.

*Management.*—The type is not very well supplied with plant food. In order to increase the nitrogen and organic matter, legumes must be grown, manure should be applied, and crop residues plowed under. Before clovers can be grown at their best, limestone to the amount of 2 or 3 tons per acre should be applied.

According to the analytical data given in Tables 2, 3, and 4, brown sandy loam is among the poorest in phosphorus of all the soil types in the county, which fact suggests that sooner or later provision must be made for correcting this deficiency. Unfortunately the Experiment Station has no experiment field on this particular soil type from which information might be drawn regarding the best form of phosphatic material to apply. The low organic content of this type of soil would suggest a possible advantage in using a directly available form of phosphate, such as steamed bone meal or acid phosphate. One hundred pounds of steamed bone meal or 200 pounds of acid phosphate of good quality will return to the soil as much of the element phosphorus as is contained in 50 bushels of wheat or 70 bushels of corn. Alfalfa and soybeans ought to do well on this soil.

### Brown Silt Loam on Tight Clay (928.1, 1128.1)

Brown silt loam on tight clay occurs on the northern half of Cayuga ridge in broken or disconnected areas. The type covers an area of 15.74 square miles, or 1.5 percent of the area of the county.

*The surface soil,* 0 to 6⅔ inches, is a brown silt loam which shows a gray color when it dries after a rain. The color is not uniform but varies so as to give the field a spotted appearance. The stratum contains about 4.8 percent of organic matter, or 48 tons per acre.

*The natural subsurface soil* is a layer from 4 to 18 inches thick consisting of a brown silt loam which passes into a compact, brownish yellow, impervious material. The stratum sampled (6⅔ to 20 inches) contains about 1.9 percent of organic matter.

*The subsoil* consists of yellowish or drabbish yellow compact material that does not permit the ready passage of air or water. The origin of this tight subsoil is difficult to explain. A similar case occurs in Iroquois county, where there is little doubt but that the subsoil was deposited in a shallow lake. One possible explanation is that the material composing this tight stratum may have been deposited during a period of recession of the glacier. When the glacier advanced, this material was pushed forward, and upon the melting of the ice was deposited upon the moraine, where it has been subsequently covered by a few inches of wind-blown material which now constitutes the soil.

One of the samples of subsoil collected showed an extremely high sulfur content amounting to 51,780 pounds per acre. Upon resampling this area, a thin deposit of white substance was found at a depth of 35 to 40 inches which, upon chemical examination, appeared to be calcium sulfate. Since this seemed to be a local abnormality, the sulfur determination for this sample is excluded from the average given in Table 4.

*Management.*—This type is lacking in limestone in the upper two strata, but the subsoil seems to contain a considerable supply of this material. For legumes, it is therefore necessary to apply limestone. Sweet clover is the best legume to grow, as its roots have the greatest power of penetration, even greater than those of alfalfa.

### Gravelly Black Clay Loam (1120.2)

Much of the black clay loam contains some gravel, but only in a few places is the gravel sufficiently abundant to form the type, gravelly black clay loam, in areas large enough to be shown as such on the map. Small areas of an acre or two are frequently met. The type occurs principally in places that were formerly sloughs containing streams which at times became swift currents. The total area of gravelly black clay loam as mapped is 205 acres, and it is confined mostly to Township 27 North, Range 6 East.

*The surface soil,* 0 to 6⅔ inches, is a black, granular, plastic, gravelly clay loam with some sand. The content of gravel varies from 20 to 30 percent. Most of the pebbles are smaller than a half inch in diameter. This stratum contains about 7.5 percent of organic matter, or 75 tons per acre.

*The natural subsurface* is a layer from 8 to 14 inches in thickness. It differs but little from the surface except that it becomes lighter in color with increasing depth until it passes into a drab or a grayish yellow. The organic matter of the sample collected (6⅔ to 20 inches) was approximately 3.4 percent, or 68 tons per acre.

*The natural subsoil,* extending to 40 inches, is somewhat more variable than the other strata but is usually a silty clay with sand and gravel. It contains about 1.2 percent of organic matter.

*Management.*—This type is well supplied with the elements of plant food. It should be managed in the same manner as the black clay loam (–20).

### Brown-Gray Silt Loam on Tight Clay (928, 1128)

Brown-gray silt loam on tight clay is widely scattered over the county, but it usually occurs in small areas. Many spots of this type, too small to be shown on the map, are included in areas of brown silt loam (—26). These spots usually occur as shallow depressions. The total area in this county, as mapped, amounts to just about one square mile.

*The surface soil,* 0 to 6⅔ inches, varies from a grayish brown to brown silt loam. It contains about 3.8 percent of organic matter, or 38 tons per acre.

*The natural subsurface* is a layer from 6 to 12 inches thick. It is a gray to brownish gray silt loam with about 1.5 percent of organic matter in the stratum sampled (6⅔ to 20 inches).

*The subsoil* is a brownish yellow clay, tough, plastic, and impervious.

*Management.*—Drainage is very necessary in the improvement of this type, but the impervious character of both subsurface and subsoil makes this land rather difficult to drain. The lines of tile must be placed much closer than in the draining of brown silt loam (—26).

The type is rather meagerly supplied with the elements of plant food and it appears to be acid in the surface stratum. The growing of legumes and the turning under of manure and crop residues will supply nitrogen, but in order to secure the best growth of legumes limestone should be applied. Sweet clover is recommended as one of the best crops to grow. After these needs are satisfied probably phosphorus will prove to be beneficial.

### Brown Silt Loam on Gravel (1126.4)

Brown silt loam on gravel occurs only in Sections 13 and 14 in Township 27 North, Range 7 East, where a gravel ridge has been covered with silt. The total area is only 173 acres.

*The surface soil,* 0 to 6⅔ inches, is a brown silt loam with some sand. It has about 3.8 percent of organic matter, or 38 tons per acre.

*The subsurface soil,* 6⅔ to 20 inches, is a brown to brownish yellow silt loam, containing about 2.5 percent of organic matter.

*The subsoil* is made up chiefly of gravel, which first appears at depths varying from 16 to 30 inches.

*Management.*—The management of the type should be the same as that recommended for brown silt loam (—26) except that, on account of the relatively shallow reservoir for holding moisture, a large amount of organic matter is even more essential than on brown silt loam. For the same reason early maturing crops should be grown.

### Brown Silt Loam on Rock (1126.5)

The total area of brown silt loam on rock in the county is 89 acres and it is found in Sections 15 and 16, Township 28 North, Range 5 East. The rock is limestone.

*The surface soil,* 0 to 6⅔ inches, is a brown silt loam with about 4.2 percent of organic matter, or 42 tons per acre.

*The subsurface* is sampled to 20 inches in depth where possible. Rock is found at depths varying from 15 to 30 inches. The subsurface as sampled contains about 2.7 percent of organic matter.

*Management.*—Shallow soils underlain by rock usually do not withstand drouth to any great extent; therefore in the management of this type it would be well to use early maturing crops, as these will be affected least by drouth. In other respects the type should be managed about the same as the ordinary brown silt loam (—26). If the soil is very shallow it will probably be best to give the land over to permanent pasture.

#### (b) UPLAND TIMBER SOILS

The upland timber soils include nearly all the upland areas that are now, or have been, covered with forests. These soils contain much less organic matter than those of the prairie. In forests the vegetable material from trees accumulates upon the surface and is either burned or suffers almost complete decay. Grasses, which furnish large amounts of humus-forming roots, do not grow to any extent because of the shade. Moreover, the organic matter that had accumulated before the timber began growing is removed thru various decomposition processes, with the result that in these soils generally the content of nitrogen and organic-matter has become too low for the best growth of farm crops.

The total area of upland timber soils in Livingston county is 21.21 square miles, or about 2 percent of the area of the county.

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

Yellow-gray silt loam is not very extensive in this county, altho it is distributed along most of the courses of the larger streams, where it forms a narrow belt on either side. The type as mapped includes some narrow, steep slopes along the bottom-lands of streams, that are really yellow silt loam but are too narrow to be shown as such on the map. In topography, it is undulating to slightly rolling and usually has good surface drainage. White oak and hickory are trees commonly found. The area covered by this type is 18.92 square miles. or about 12,000 acres.

*The surface soil,* 0 to 6⅔ inches, is a gray or yellowish gray silt loam, incoherent and mealy, but not granular. In physical composition it varies according to its relation to other types. Where it occurs in the sandy loam areas it sometimes becomes somewhat sandy, and very small areas may contain enough sand to be mapped as yellow-gray sandy loam. The organic-matter content averages about 2.7 percent, or 27 tons per acre. The amount increases where the type grades into the brown silt loam which usually borders it.

*The natural subsurface stratum* varies from 3 to 10 inches in thickness. In color it is gray, grayish yellow, or yellow. It is somewhat pulverulent, but becomes more coherent and plastic with increasing depth. The amount of organic matter of the stratum sampled (6⅔ to 20 inches) is about .9 percent.

*The subsoil* is a yellow or grayish yellow clayey silt or silty clay, somewhat plastic when wet but pervious to water. Sometimes the subsoil is made up wholly or in part of glacial material.

*Management.*—In the management of yellow-gray silt loam, one of the essential considerations is the maintenance or increase of organic matter. This is even more necessary with the yellow-gray silt loam than with the brown silt loam because of the fact that this soil is naturally much lower in organic matter, having only about one-half as much as the brown silt loam. The deficiency in organic matter permits the soil particles to run together, in the wetting by heavy rains. Organic matter will help to prevent washing on the more rolling areas. As it decays, it supplies nitrogen and at the same time tends to liberate other plant-food elements, as explained in the Appendix.

In the areas sampled, the soil is acid, thus making it necessary to apply 2 or 3 tons of ground limestone per acre before the best results can be obtained with legumes. Later applications may be smaller. The growth of legumes is very essential since they furnish organic matter to turn back into the soil and at the same time supply the necessary nitrogen. But all forms of organic matter, such as corn stalks, manure, and weeds are of value and they should be turned into the soil rather than burned.

On the experiment field in Lake county representing this soil type, excellent results have been obtained by the use of steamed bone meal.

### Yellow Silt Loam (935, 1135)

Yellow silt loam is found on steep slopes along the streams and on the steepest parts of moraines. It covers an area of 1,325 acres.

*The surface soil,* 0 to 6⅔ inches, consists of a yellow to brownish yellow silt loam varying in composition from a sandy phase on the one hand, to a rather heavy phase on the other. The surface stratum contains about 3.2 percent of organic matter, or 32 tons per acre.

*The subsurface* is a yellow silty or sandy material varying toward a silty clay. The stratum contains about one percent of organic matter.

*The subsoil* is a yellow clayey silt and in many cases is formed from boulder clay.

This type is usually not under cultivation and practically the only way in which it can be used is as pasture or as woodland.

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

With only a few exceptions, yellow-gray sandy loam occurs adjacent to the streams in a manner similar to yellow-gray silt loam. The type is usually slightly rolling. It covers an area of 141 acres.

*The surface soil,* 0 to 6⅔ inches, is a gray to yellow-gray sandy loam containing about 2 percent of organic matter, or 20 tons per acre.

*The subsurface* is a sandy loam varying in color from yellow to grayish yellow. It contains .5 percent of organic matter.

*The subsoil* varies considerably, being made up in some places of a yellowish, sandy, clayey material, while in others it is composed of boulder clay, and in still others of sand.

*Management.*—As a type, yellow-gray sandy loam is somewhat inferior to most other soils of the county. It is low in practically all elements of fertility. In the samples analyzed, carbonates were lacking even in the subsoil. Where such a condition exists, 2 to 4 tons of limestone per acre should be applied so that legumes will grow well. The legumes should be turned under in order to increase the amount of nitrogen, which is now much too low for a productive soil. All organic residues should be put back into the soil for the same purpose. The type is low in phosphorus, and ultimately this element must be supplied if the best results are to be obtained in the growth of crops. The same remarks regarding phosphorus apply here as are given in connection with brown sandy loam (—60).

### (c) TERRACE SOILS

The terrace soils in this county were formed by the flooding of a valley during the melting of the glacier. The stream carried large amounts of coarse sand and gravel which were deposited as its velocity decreased. Finer material later deposited over this sand and gravel forms the present soil. When the stream reached its normal size after the glacier had melted, it cut down thru the deposit so deep that the terrace is no longer flooded at times of overflow. The depth of the finer material that forms the soil varies in this county from about 16 inches to four or five feet. The value of these soils depends much upon the depth to gravel. If the gravel is too near the surface, the crops may suffer from drouth. The total area of terrace soils in Livingston county is about 20 square miles.

### Brown Silt Loam over Gravel (1527)

Brown silt loam over gravel is found along the Vermilion river above the rock ledge or rock ridge which the river crosses just below Pontiac. The topography is usually flat to undulating. The total area is 13.39 square miles, or 1.3 percent of the area of the county.

*The surface soil,* 0 to 6⅔ inches, is a little lighter in color than the upland brown silt loam. It varies somewhat in composition, being distinctly sandy in some places. It contains about 2.9 percent of organic matter, or 29 tons per acre.

*The natural subsurface* consists of a silt loam stratum varying from 6 to 12 inches in thickness. It varies in color from brown to light brown. The stratum sampled (6⅔ to 20 inches) contains about 2.5 percent of organic matter, or 50 tons per acre.

*The subsoil* varies from a yellow silt to a yellow sandy silt. In most instances gravel is found at a depth of 30 to 48 inches. This provides good drainage where the water table is sufficiently low.

*Management.*—In the samples examined, all strata of this type were acid. In cases where this is the condition, 2 or 3 tons of limestone will be required as an initial application in order to provide favorable conditions for the growth of legumes. Later applications should be made in quantity sufficient to maintain these conditions. The same need for applying phosphorus and for turning under legumes and organic residues exists in this type as in the upland brown silt loam. Excellent results have been obtained in the use of rock phosphate in building up land on this soil type.

### Brown Sandy Loam over Gravel (1566)

Brown sandy loam over gravel occurs along the Vermilion river. It owes its formation to the same general processes as the preceding type (1527). It includes a total area of 1,453 acres.

*The surface soil,* 0 to 6⅔ inches, is a brown sandy loam varying on the one hand to brown silt loam, and on the other to sand. It contains about 3.8 percent of organic matter, or 38 tons per acre.

*The subsurface* is a brown sandy loam, passing into a yellowish sandy silt at a depth of about 15 inches. It contains about 1.6 percent of organic matter.

*The subsoil* is a yellow sandy silt varying to a silt. The gravel is sometimes found at a depth of less than 40 inches altho it usually occurs at greater depths.

*Management.*—In the sample analyzed, all strata were acid. Where this condition occurs it will be necessary to apply 2 or 3 tons of limestone to secure the best results with legumes. The same use must be made of organic residues and manure as recommended for the preceding type. The remarks made in connection with the management of brown sandy loam, page 17, will also apply here.

### Black Clay Loam (1520)

A few areas of black clay loam occur in the poorly drained parts of the terrace. This type covers a total of 813 acres. It differs but little, if any, from the upland type of black clay loam. (See page 15.)

### Yellow-Gray Silt Loam over Gravel (1536)

Yellow-gray silt loam over gravel occurs along the upper course of the Vermilion river and its two tributaries—Indian and Forrest creeks. The total area of the type is 1,197 acres.

*The surface soil,* 0 to 6⅔ inches, is a yellowish or grayish yellow silt loam varying in sand content to a loam and in some places even to a sandy loam.

*The subsurface soil* is a yellow silt loam.

*The subsoil* is a yellow silty clay or clayey silt, underlain by medium gravel, which is generally below 40 inches.

*Management.*—In the management of this type, one of the first requirements is an application of 2 to 3 tons of limestone in order to correct the acidity which in the subsoil becomes very high. The low content of organic matter demands that legumes be grown and that the best use be made of crop residues, and manure. Along with the improvement in this way, it would be of benefit to apply some form of phosphate—probably one of the more available forms, such as bone meal or acid phosphate, would be preferable. This would be a good soil for alfalfa, as it is generally well drained owing to the underlying stratum of gravel.

### Brown Silt Loam on Gravel (1526.4)

Brown silt loam on gravel occurs to a limited extent along Indian and Forrest creeks west of Forrest. It covers only 378 acres.

*The surface soil,* 0 to 6⅔ inches, is lighter in color than the upland brown silt loam. It contains about 3 percent of organic matter.

*The subsurface soil* is a yellowish brown or brownish yellow silt loam.

*The subsoil* is a yellow sandy or gravelly silt loam passing into gravel at a depth of about 16 to 28 inches.

*Management.*—This type requires the same treatment as brown silt loam on gravel of the upland (1126.4).

### Black Sandy Loam (1561)

Black sandy loam occurs to the extent of only 32 acres.

*The surface soil* is a black sandy loam containing 6.3 percent of organic matter.

*The subsurface soil* is a sandy loam changing from black to drabbish yellow and carrying about 3 percent of organic matter.

*The subsoil* is a drabbish yellow sandy loam containing some coarse sand.

*Management.*—Good cultivation, together with the application of limestone when the soil becomes deficient in this constituent, is the essential thing in handling this land.

### Yellow-Gray Sandy Loam over Gravel (1567)

Yellow-gray sandy loam over gravel occurs along the streams in a manner similar to that of brown sandy loam over gravel, but it has been timbered sufficiently long to reduce the organic matter to a very small amount. This type covers an area of 166 acres.

*The surface soil,* 0 to 6⅔ inches, is a gray to light yellow sandy loam. It ranges in texture from a loam to a very sandy phase of sandy loam. It contains about 2.5 percent of organic matter, or 25 tons per acre.

*The subsurface soil* is a gray or yellowish gray sandy loam, passing into the heavier phase characteristic of the subsoil at a depth of about 15 to 17 inches.

*The subsoil* consists usually of a sandy, clayey material that is underlain by gravel at a depth of 36 to 54 inches.

*Management.*—Since this type is very low in nitrogen, containing only 2,520 pounds per acre in the plowed soil, the growing of legumes should receive primary consideration. The soil as sampled indicates the absence of limestone; therefore it is necessary to apply 2 to 4 tons per acre in order to produce the best growth of legumes. All available organic residues and farmyard manure must be turned under in order to increase and maintain the supply of organic matter and nitrogen. This soil is also very low in phosphorus and this element should be supplied as recommended for brown sandy loam, page 17.

### Brown-Gray Silt Loam on Tight Clay (1528)

Brown-gray silt loam on tight clay is rather common in the terrace, altho the total area mapped as such amounts to only 89 acres. The individual areas are small, and there are many spots corresponding to this type that are too small to be shown on the map. They constitute small depressions of gray soil that formerly were ponds.

*The surface soil,* 0 to 6⅔ inches, is a grayish brown silt loam containing 6 percent of organic matter, which is a rather high percentage for this type.

*The natural subsurface stratum,* which is about 10 inches thick, is very gray in color.

*The natural subsoil,* which immediately underlies the gray stratum, is heavy and tight, and this may in turn be underlain by sand.

*Management.*—The type is fairly well supplied with elements of plant food, but in the area sampled the soil is acid, thus indicating that limestone is necessary in order to get the best results with legumes. Probably phosphate would be profitably applied on these areas. Drainage is very essential but is rather difficult to secure.

### Brown-Gray Sandy Loam on Tight Clay (1568)

In some places where tight clay has formed, sand has been carried to the area either by wind or water, and there is formed a brown-gray sandy loam on tight clay that has the same characteristics as the preceding type except that it is not so well supplied with the elements of plant food. There are 45 acres of the type.

*The surface soil,* 0 to 6⅔ inches, is a brownish gray to gray sandy loam containing about 2.9 percent of organic matter, or 29 tons per acre.

*The subsurface* is a gray sandy loam underlain at 14 to 17 inches by a tough, tight, plastic, sandy clay. The stratum as sampled (6⅔ to 20 inches) contains about 1.3 percent of organic matter.

*The subsoil* is a tough, impervious, sandy clay that is underlain by coarse sand at a depth of 36 to 48 inches.

*Management.*—This soil is low in plant food. In order to improve it, limestone should be applied, legumes should be grown, and all available manure and other forms of organic matter should be plowed under. Phosphorus should also be supplied. See recommendations for brown sandy loam, page 17.

### (d) LATE SWAMP AND BOTTOM-LAND SOILS

This group includes the bottom lands along the streams, the swamps, and the poorly drained lowlands. Much of the soil, therefore, is of alluvial formation and the land is largely subject to overflow. The swamps occupy low, marshy places. In former times these swamps became, during wet seasons, shallow ponds or lakes. Five types of this group are recognized in Livingston county, the total area of which aggregates 22.40 square miles, or about 2.17 percent of the county.

## Mixed Loam (1454)

The common type of bottom land of Livingston county is mixed loam. It occurs in irregular strips, rarely more than a quarter of a mile wide, along the Vermilion river and its tributaries and also along the west branch of the Mazon river. It covers a total area of 20.96 square miles, or 13,414 acres. This type is a mixture of types, as its name implies; black clay loam, brown silt loam, brown loam, brown sandy loam, and even sand may all be found. Even if it were possible to indicate on the map the many variations, the effort would be useless because the next flood would probably leave a different mixture.

*The surface soil,* 0 to 6⅔ inches, is a mixed loam varying from clay loam to sand and, as sampled, containing approximately 5.9 percent of organic matter, or 59 tons per acre.

*The subsurface soil,* 6⅔ to 20 inches, is a brown mixed loam with about 4.7 percent of organic matter, according to the sample taken.

*The subsoil* probably varies more than the other strata. As sampled it contains about 2.4 percent of organic matter.

*Management.*—The type is not of great importance except for pasture. The essential factor in its management is good cultivation. Renewal by frequent overflows will maintain the fertility.

## Deep Brown Silt Loam (1426)

Deep brown silt loam occurs only to the extent of 320 acres, and is located principally along the branches of the Mazon river in the northeastern part of the county.

*The surface soil,* 0 to 6⅔ inches, is a brown silt loam containing about 7 percent of organic matter.

*The subsurface soil,* 6⅔ to 20 inches, consists of a brown silt loam containing more or less sand. The organic-matter content is about 4.1 percent.

*The subsoil* varies from a brown silt loam to a brownish yellow silt loam. It contains about 1.8 percent of organic matter.

*Management.*—This type is well supplied with all elements of plant food and the main consideration in its management at present is good cultivation. As time goes on attention should be given to the need for limestone.

## Deep Peat (1401)

Most of the deep peat is found in Townships 25 and 26 North, Range 8 East, where it occurs in rather deep depressions in the moraine. The total area of the type is 563 acres.

*The surface soil,* 0 to 6⅔ inches, is a black to brown peat containing a considerable percentage of shells in some local areas. These give a decidedly alkaline character to the soil.

*The subsurface soil,* 6⅔ to 20 inches, is a brown to black peat.

*The subsoil* is a brown to black peat, varying in the shallower areas to clayey material which may form a part of the subsoil.

*Management.*—Drainage is the first requirement of this type. Some parts have been drained and crops have been grown. The type, however, is low in the element potassium, as is characteristic of peat, and an application of some form of potassium will probably be necessary before success can be obtained with corn and oats. For the results of field experiments on deep peat, see page 54 of the Supplement.

### Medium Peat on Clay (1402)

The area mapped as medium peat on clay amounts to only 32 acres. Altho mapped as medium peat on clay, which would presume the peat to be not more than 30 inches deep, in reality the thickness of the peaty layer is extremely variable. In some spots the clay occurs within a few inches of the surface, while at other places a boring of 60 inches reveals nothing but peaty material. Evidently the sample taken for chemical analysis was collected from one of these spots of deeper peat, as the high contents of carbon and nitrogen would indicate.

*Management.*—In general this land should receive the same management as that suggested for deep peat (1401).

### Muck on Marl (1413.6)

The only area of muck on marl in this county occurs in the southeast quarter of Section 32, Township 30 North, Range 7 East.

*The surface soil,* 0 to 6⅔ inches, is a black clayey material containing about 23 percent of organic matter.

*The subsurface and subsoil* are not uniform, but are made up of layers of marl alternating with clayey material. The samples examined contained about 5 percent of organic matter in the subsurface and 2 percent in the subsoil.

*Management.*—This type should be managed in the same way as black clay loam (–20).

### (e) RESIDUAL SOILS

A residual soil is one which has not been transported thru the action of glacier, wind, or water, but is formed *in place* by the weathering of rocks and the accumulation of organic matter. Rock outcrops are also included in this group.

### Stony Loam (098)

The only area of stony loam in the county is found in Section 1, Township 27 North, Range 5 East. This is a small area where the underlying rock comes close to the surface. The shallow soil partakes of the character of brown silt loam and is mixed with loose pieces of the partially weathered rock. At the highest part of the area the bare rock is exposed, and from this extreme the type merges gradually into typical brown silt loam. This outcrop affords a source of excellent limestone for soil improvement. A sample gave a purity test of nearly 99 percent of calcium carbonate equivalent.

# 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 | 2.80 | 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 | 18 |
| 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, vetches, and alfalfa 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 cereal crops which follow in the rotation, and which are less independent feeders. Moreover, as an effect of the deep rooting habit of these legumes, large quantities of mineral plant-food elements 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, somewhat more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds roughly to 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. In case the magnesium content of the soil is low, 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 ($CaCO_3$) may be used. 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 the following test 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 Potassium Thiocyanate Test for Acidity.** This test for soil acidity 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. An excess of water interferes with the test. In testing, therefore, the soil should not be wetter than it would be when in good tillable condition. 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.

It should always be borne in mind in connection with the application of phosphorus to the land that the addition of phosphorus, or of any other fertilizing substance, to the soil can exert no benefit until the need of it has become a limiting factor of production. For example, if there is already present in the soil sufficient available phosphorus to produce a forty-bushel crop, and the nitrogen supply or the moisture supply is sufficient for only forty bushels, or less, then extra phosphorus added to the soil cannot increase the yield beyond this forty-bushel limit.

There are several different materials containing phosphorus which are applied to land as fertilizer. The more important of these are bone meal, acid phosphate, natural raw rock phosphate, and basic slag. Obviously that carrier of phosphorus which gives the most economical returns, as considered from all standpoints, is the most suitable one to use. Altho this matter has been the subject of much discussion and investigation the question still remains unsettled. Probably there is no single carrier of phosphorus that will prove to be the most economical one to use under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

Bone meal, prepared from the bones of animals, appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen which adds a useless expense if the material is purchased for the sake of the phosphorus. As a source of phosphorus, steamed bone meal is preferable to raw bone meal. Steamed bone meal is prepared by extracting most of the nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. Acid phosphate also contains besides phosphorus, sulfur, which is another plant-food element. The phosphorus in acid phosphate is more readily available for absorption by plants than that of raw rock phosphate. Acid phosphate of good quality should contain 6 percent or more of the element phosphorus.

Rock phosphate, sometimes called floats, is a mineral substance found in vast deposits in certain regions. The phosphorus in this mineral exists chemically as tri-calcium phosphate and a good grade of the rock should contain 12½ percent, or more, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

The relative cheapness of raw rock phosphate, as compared with the treated or acidulated material, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in this form than in the form of acid phosphate, the ratio being, under the market conditions of the past several years, about 4 to 1. That is to say, under these market conditions, a dollar will purchase about four times as much of the element phosphorus in the form of rock phosphate as in the form of acid phosphate, which is an important consideration if one is interested in building up a phosphorus reserve in the soil. As explained above, more very carefully conducted comparisons on various soil types under various cropping systems are needed before definite statements can be given as to which form of phosphate is most economical to use in all situations.

Basic slag, known also as Thomas phosphate, is another carrier of phosphorus that might be mentioned because of its considerable usage in Europe and eastern United States. Basic slag phosphate is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore it tends to influence to some extent the soil reaction.

Rock 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.

In using acid phosphate or bone meal in a cropping system which includes wheat, it is a common practice to apply the material in the preparation of the wheat ground. It may be advantageous, however, to divide the total amount to be used and apply a portion to the other crops of the rotation, particularly to corn and to clover.

## The Potassium Problem

Our most common 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 common 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.

The annual loss of limestone from the soil depends, of course, upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of carbonates from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests described on pages 35 and 36, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

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, as in the burning of coal, 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 with 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 effect becomes worse 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* —Wheat or oats (with clover)
*Third year* —Clover
*Fourth year* —Wheat (with clover)

*First year* —Corn
*Second year* —Corn
*Third year* —Wheat or oats (with clover)
*Fourth year* —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 Livingston 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 further 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. If the red clover crop fails, soybeans are substituted.

### Soil Treatment

The treatment applied to the plots has, for the most part, been standardized according to a rather definite system, altho deviations from this system occur now and then, particularly in the older fields.

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.*—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 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 records 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.

TABLE 3.—URBANA FIELD, DAVENPORT PLOTS: BROWN SILT LOAM, PRAIRIE; EARLY WISCONSIN GLACIATION

Ten-Year 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.

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 bone meal and rock phosphate, 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 amounts of the elements of plant food.

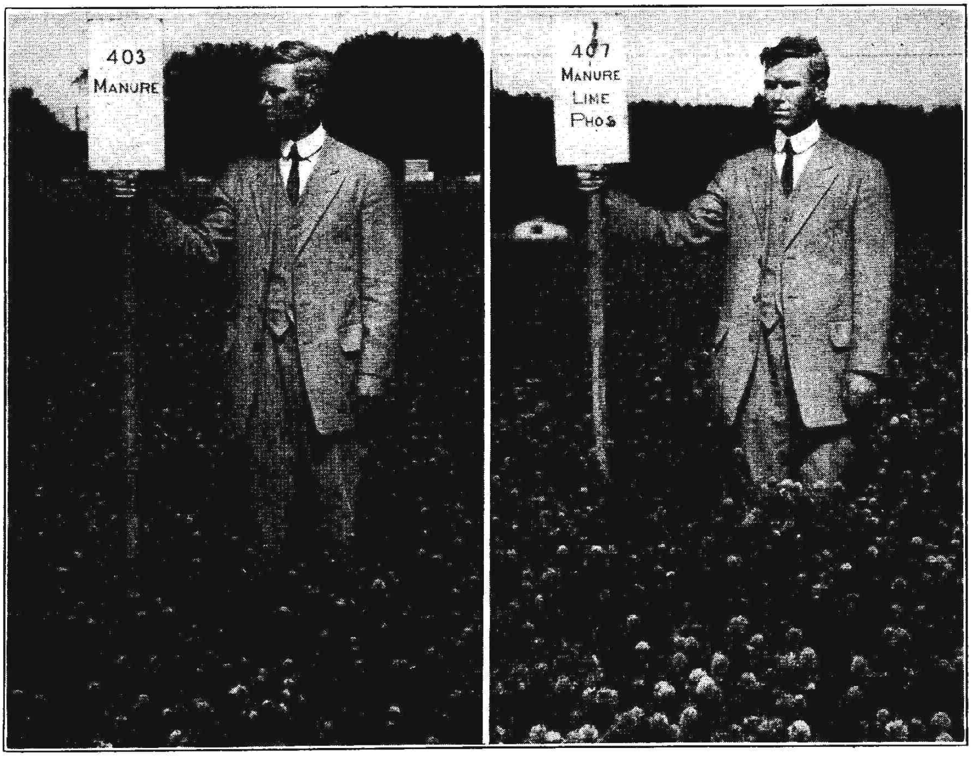
It will be observed that the applications described above provide for the two rather distinct systems of farming already described. *The grain system,* in which animal manure is not produced and where the organic matter is provided by the direct return to the soil of all crop residues along with legumes, 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.

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.

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

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

Average Annual Yields—Bushels or (tons) per acre

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 | 33.5 | | (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.

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, residues alone 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.

Limestone, which has been used in the southwest rotation, appears to have produced no increase of consequence to any of the crops except oats. The comparison may be somewhat impaired, however, 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 of especial interest because this element has been applied to these plots in all three rotations 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.

TABLE 5.—COMPARING PRODUCTION OF CORN IN THREE DIFFERENT ROTATION SYSTEMS
ACRE 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 Joliet and Minonk Fields

Data from two fields on brown silt loam located in the vicinity of Livingston county are introduced here. One of these fields is located near Joliet in Will county and the other at Minonk in Woodford county. The lay-out of plots and the crop rotations on the two fields are alike. The summarized results of the three grain crops, corn, oats, and wheat, are given in Table 6, the yields for the legume crops being for the present purpose disregarded.

In considering the results from these two fields it should be pointed out that they represent opposite phases of the brown silt loam type, the Joliet field being situated on a rather light phase while the Minonk field lies on a very heavy phase, approaching, in fact, black clay loam in character. Moreover, the crop yields on the untreated land (Plots 1, 5, and 10) indicate that the Minonk field is on a considerably higher plane of natural productiveness than the Joliet field, which fact may account to a large extent for some of the discrepancies in response to soil treatment.

In looking over the results presented in Table 6, one of the first points of interest is the effect of farm manure. On both of these fields manure has produced a decided increase in yield of corn, and with the exception of the oats at Minonk, there has been a beneficial effect on all crops. This suggests the importance of carefully saving and regularly applying all available animal manure.

TABLE 6.—JOLIET and MINONK FIELDS: BROWN SILT LOAM, PRAIRIE; JOLIET, LATE WISCONSIN GLACIATION; MINONK, EARLY WISCONSIN GLACIATION

Average Annual Grain Yields—Bushels per acre

| Soil treatment applied | Joliet Field (1915-1922) | | | Minonk Field (1912-1922) | | |
|---|---|---|---|---|---|---|
| | Corn 10 crops | Oats 7 crops | Wheat 5 crops | Corn 11 crops | Oats 10 crops | Wheat 8 crops |
| 0 | 28.1 | 61.1 | 25.4 | 51.4 | 59.9 | 34.1 |
| M | 36.3 | 66.8 | 30.3 | 60.2 | 59.8 | 36.9 |
| ML | 40.2 | 68.0 | 35.2 | 61.7 | 60.3 | 34.4 |
| MLP | 42.9 | 72.8 | 41.9 | 62.5 | 59.3 | 36.1 |
| 0 | 29.2 | 62.0 | 25.1 | 51.7 | 56.3 | 34.2 |
| R | 33.5 | 62.4 | 27.9 | 59.3 | 60.9 | 35.4 |
| RL | 37.4 | 63.2 | 28.9 | 62.1 | 61.0 | 32.6 |
| RLP | 41.7 | 67.8 | 38.7 | 61.4 | 63.2 | 34.3 |
| RLPK | 46.4 | 70.6 | 41.1 | 60.2 | 63.1 | 33.2 |
| 0 | 31.9 | 62.9 | 26.5 | 48.0 | 57.3 | 28.2 |
| **Increases—Bushels per acre** | | | | | | |
| M over 0 | 8.2 | 5.7 | 4.9 | 8.8 | −0.1 | 2.8 |
| ML over M | 3.9 | 1.2 | 4.9 | 1.5 | 0.5 | −2.2 |
| MLP over ML | 2.7 | 4.8 | 6.7 | 0.8 | −1.0 | 1.7 |
| R over 0 | 4.3 | 0.4 | 2.8 | 7.6 | 4.6 | 1.2 |
| RL over R | 3.9 | 0.8 | 1.0 | 2.8 | 0.1 | −2.8 |
| RLP over RL | 4.3 | 4.6 | 9.8 | −0.7 | 2.2 | 1.7 |
| RLPK over RLP | 4.7 | 2.8 | 2.4 | −1.2 | −0.1 | −1.1 |

Residues, alone, has likewise given a substantial increase in corn, altho the response by the other crops is not so marked.

Limestone has given variable results. On the Joliet field all crops have shown some benefit from the use of limestone. On the other hand, the increases due to limestone on the Minonk field are not significant, some of the effects even appearing as negative. The behavior of limestone on these two fields is characteristic for the brown silt loam of this region. Some of the land is in need of limestone and some of it is not. The limestone requirement, therefore, cannot be covered by a general prescription; rather, it is a matter which must be determined for each individual farm or even for each individual field.

Rock phosphate has given very favorable returns as measured by increases in crop yields on the Joliet field. On the Minonk field, however, the opposite is true. The small differences appearing as the effect of the treatment are probably not significant, being within the range of the experimental error due to the natural plot variation. This variation in response to rock phosphate on brown silt loam is likewise characteristic. On some experiment fields very pronounced and consistent gains have attended the use of this material. On certain other fields, however, where it has been applied in the same amounts and in similar manner, it has not produced sufficient increase to cover the cost. It remains for further investigation to explain this discrepancy.

The potassium fertilizer on the Joliet field has apparently produced a profitable gain, but on the Minonk field all of the "increases" are negative. The favorable results for potassium at Joliet are unusual for this soil type. There is usually little or no response in the grain crops to potassium treatment on brown silt loam.

## 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.

The results of the four years' tests, as given in Table 8, 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.

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.

TABLE 7.—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.; Acidulated bone, 350 lb. | 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.

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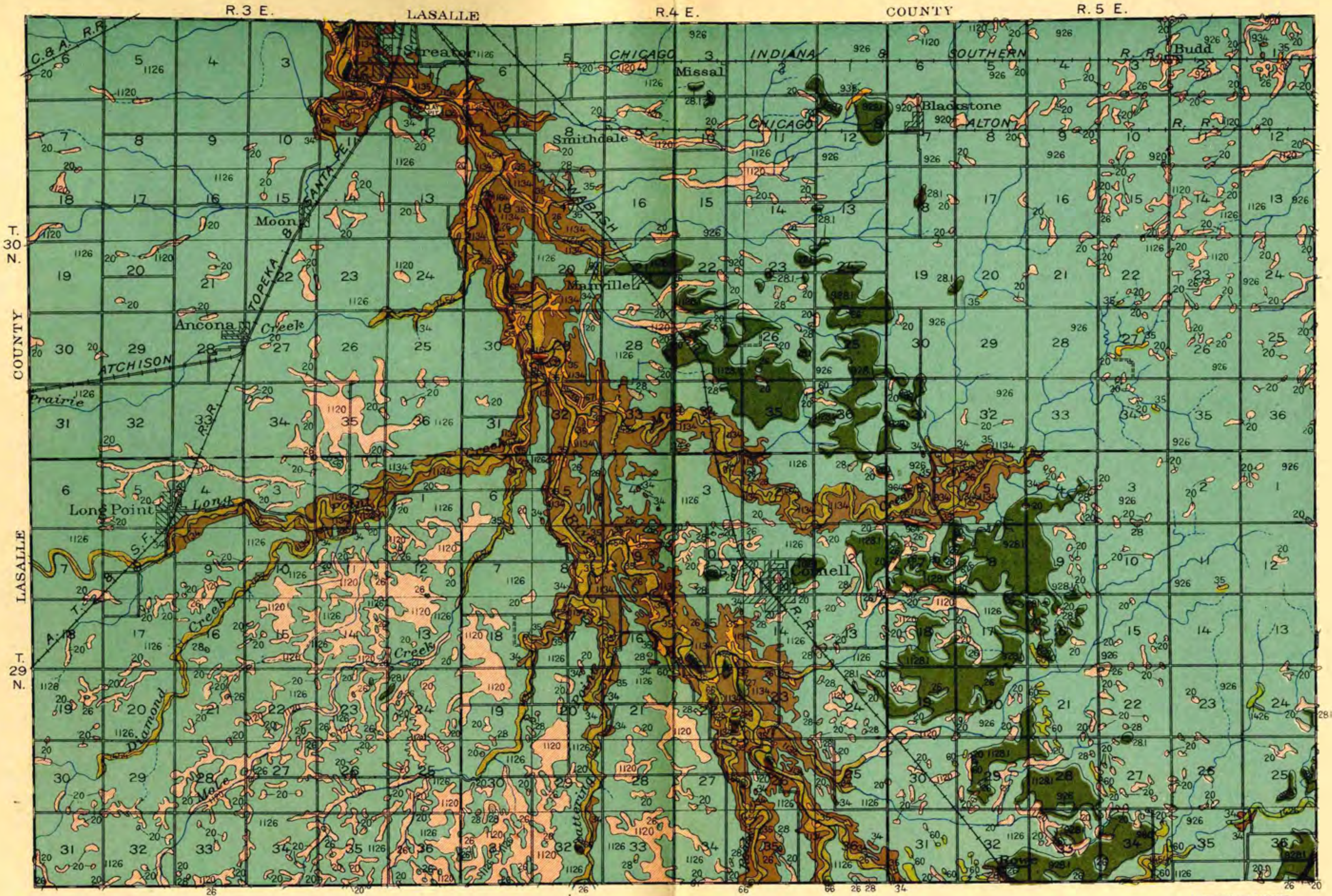


## LEGEND

900 Early Wisconsin Moraines

1100 Early Wisconsin Intermorainal Areas

(a) UPLAND PRAIRIE SOILS

- 26 Brown silt loam
- 20 Black clay loam
- 60 Brown sandy loam
- 281 Brown silt loam on tight clay
- 1120.2 Gravelly black clay loam
- 28 Brown-gray silt loam on tight clay
- 26.4 / 1126.4 Brown silt loam on gravel
- 1126.5 Brown silt loam on rock

(b) UPLAND TIMBER SOILS

- 34 Yellow-gray silt loam
- 35 Yellow silt loam
- 364 / 1164 Yellow-gray sandy loam

(c) 1500 TERRACE SOILS

- 27 / 1527 Brown silt loam over gravel
- [illegible] Brown sandy loam over gravel
- 20 / 1520 Black clay loam
- 1536 Yellow-gray silt loam over gravel
- 1526.4 Brown silt loam on gravel
- 1561 Black sandy loam
- 67 / 1567 Yellow-gray sandy loam over gravel
- 28 / 1528 Brown-gray silt loam on tight clay
- 1568 Brown-gray sandy loam on tight clay

(d) 1400 LATE SWAMP AND BOTTOM-LAND SOILS

- 1454 Mixed loam
- 1426 Deep brown silt loam
- 1401 Deep peat
- 1402 Medium peat on clay
- 1413.6 Muck on marl

(e) 000 RESIDUAL SOIL

- 098 Stony loam

Scale
0 ¼ ½ 1 2 Miles

# SOIL SURVEY MAP OF LIVINGSTON COUNTY
## UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

## LEGEND

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- 35 Yellow silt loam
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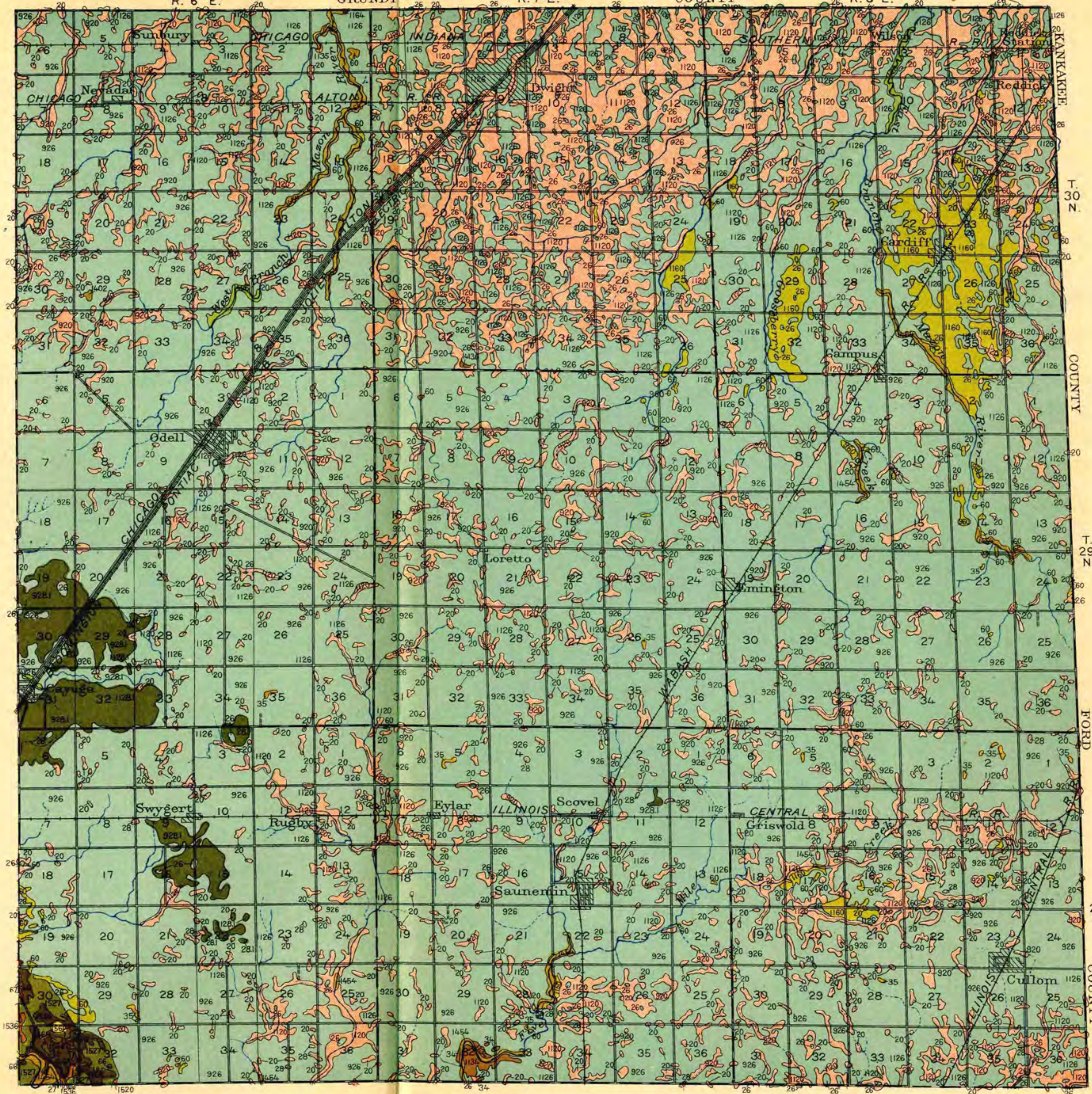
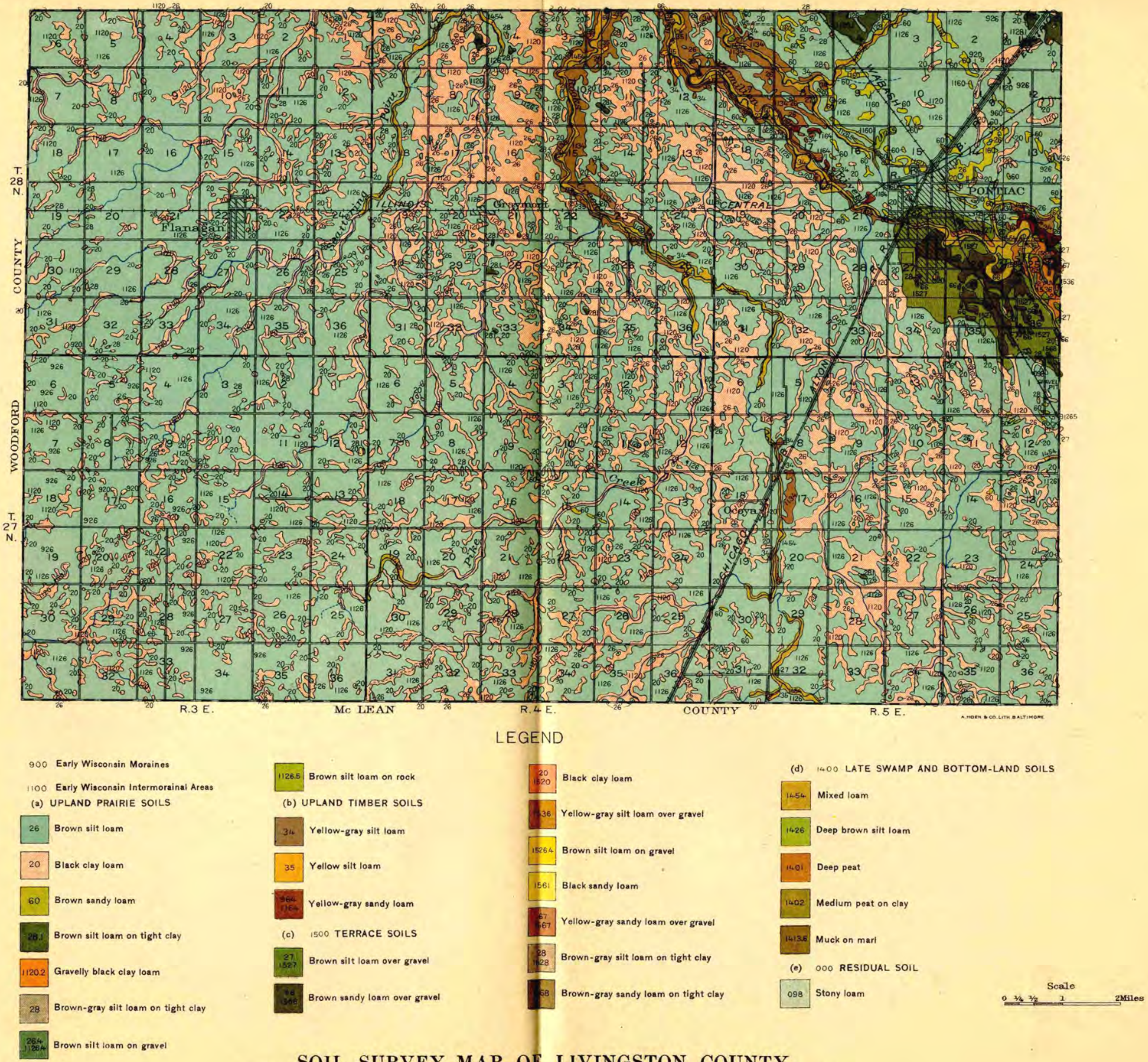
Scale 0 ¼ ½ 1 2 Miles




# SOIL SURVEY MAP OF LIVINGSTON COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

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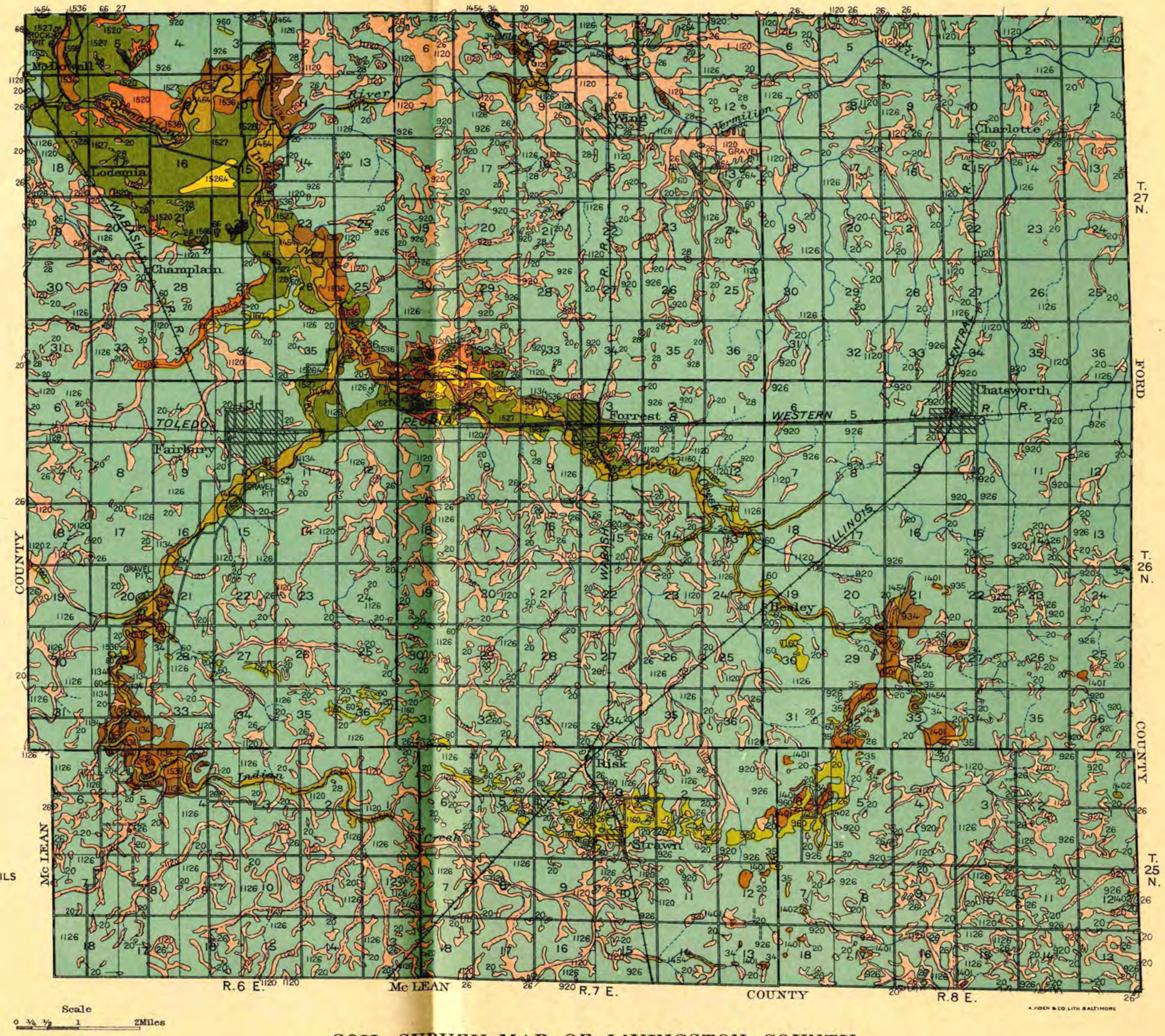


**SOIL SURVEY MAP OF LIVINGSTON COUNTY**

**UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION**