UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 26

GRUNDY COUNTY SOILS

BY R. S. SMITH, E. E. DE TURK, F. C. BAUER,
AND L. H. SMITH

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The Soil Survey of Illinois was organized under the general supervision of Professor Cyril G. Hopkins, with Professor Jeremiah G. Mosier directly in charge of soil classification and mapping. After working in association on this undertaking for eighteen years, Professor Hopkins died and Professor Mosier followed two years later. The work of these two men enters so intimately into the whole project of the Illinois Soil Survey that it is impossible to disassociate their names from the individual county reports. Therefore recognition is hereby accorded Professors Hopkins and Mosier for their contribution to the work resulting in this publication.

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.

While the authors must assume the responsibility for the presentation of this report, it should be understood that the material for the report represents the contribution of a considerable number of the present and former members of the Agronomy Department working in their respective lines of soil mapping, soil analysis, and experiment field investigation. In this connection special recognition is due the late Professor J. G. Mosier, under whose direction the soil survey of Grundy county was conducted, and to Mr. S. V. Holt, who was in direct charge of the field party in the construction of the map.

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SUPPLEMENT

GRUNDY COUNTY SOILS

BY R. S. SMITH, E. E. DE TURK, F. C. BAUER, AND L. H. SMITH[1]

LOCATION AND CLIMATE OF GRUNDY COUNTY

Grundy county is located in the northeastern part of Illinois about 70 miles from the northern boundary and covers an area of about 427 square miles. It lies principally in the early Wisconsin glaciation. The topography is, in general, gently undulating. About 65 percent of the area of the county is covered by prairie soils, 3 percent by timber soils, 23 percent by terrace soils, most of which are sandy, and 6 percent by swamp and bottom-land soils.

The climate of Grundy county is characterized by a wide range between the temperature extremes of winter and summer. Since there is no weather station of long standing in the county, the following data are taken from the Joliet station, which is located 12 miles from the northeast corner of Grundy county. The records for the years 1895 to 1920 show that the lowest temperature was 25° below zero in 1914, while the highest temperature for that year was 101°, thus making a range of 126 degrees. The highest temperature on record was 103° in 1897 and again in 1916. During the period from 1895 to 1920 the temperature reached zero or below every winter except one, that of 1906, in which the lowest temperature was 3° above; but in twenty-one winters in this period the temperature dropped to 10° or more below zero. The average date of the last killing frost in spring is May 1; the earliest in fall, October 9. The growing season, therefore, on the average, is about 161 days long.

The average annual precipitation at Joliet from 1894 to 1921 was 32.70 inches. The distribution of rainfall thruout the year is good, as shown by the following monthly averages: January, 1.89 inches; February, 1.58; March, 2.62; April, 2.69; May, 3.97; June, 3.30; July, 3.24; August, 3.27; September, 3.54; October, 2.59; November, 2.08; and December, 1.93. The proportion of total rainfall occurring during each season was: winter, 16.5 percent; spring, 28.4 percent; summer, 30.0 percent; autumn, 25.1 percent.

AGRICULTURAL PRODUCTION

Grundy county, like the other counties in this section, is primarily agricultural. It formerly contained a large acreage of what was classed as swamp land. However, in more recent years this land has been fairly well drained, so that but little actual swamp land now exists, altho much of the land might be more thoroly drained to its advantage.

In 1919 there were 1,506 farms in Grundy county, according to the Fourteenth Census of the United States. The average size of farm was 166.7 acres, 149.4 acres of which was improved land.

[1] R. S. Smith, in charge of soil survey mapping; E. E. DeTurk, in charge of soil analysis; F. C. Bauer, in charge of experiment fields; L. H. Smith, in charge of publications.

From this same census report we learn that about 72 percent of the area of the county is devoted to the production of field crops. The following figures show the acreage and production of the principal crops grown in the county. In considering these data, it must be remembered that the figures are for but a single year—that of 1919.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	87,321	3,306,486 bu.	37.9 bu.
Oats	55,662	1,713,317 bu.	30.8 bu.
Wheat	33,097	590,511 bu.	17.8 bu.
Barley	392	8,745 bu.	22.3 bu.
Rye	4,310	51,449 bu.	11.9 bu.
Timothy	2,932	3,420 tons	1.17 tons
Timothy and clover mixed	3,091	3,694 tons	1.20 tons
Clover	3,570	4,515 tons	1.26 tons
Alfalfa	982	1,808 tons	1.84 tons
Silage crops	2,061	13,533 tons	6.57 tons
Corn for forage	566	1,243 tons	2.20 tons

The total value of all crops for 1919 was $8,205,682. According to data obtained from other sources, the area devoted to pasture is about 55,000 acres.

A crop not mentioned as such in the census report, but which is rapidly gaining prominence in Grundy county, is sweet clover. There is great interest in sweet clover, not only as a source of organic matter and nitrogen for soil improvement, but also as a valuable hay, seed, and pasture crop, and thousands of acres are now given over to its production.

The live-stock interests are of considerable importance, as shown by the following figures taken from this same census report.

Animals and animal products	*Number*	*Value*
Horses	11,851	$1,603,749
Mules	637	78,878
Beef cattle	8,421	563,097
Dairy cattle	8,676	523,779
Sheep	1,847	28,663
Swine	23,058	521,981
Chickens and other poultry	168,120	174,539
Eggs and chickens	——	502,153
Dairy products	——	247,798

The total value of the live-stock and their products was, according to these figures, a little over four million dollars.

Fruit growing has not been an important feature in the agricultural production of Grundy county. In 1919 there were about 9,000 quarts of berries produced and 3,240 bushels of apples, peaches, pears, and cherries. More attention might well be given to the production of fruit, especially for home use.

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, west of Hudson Bay, and in the Rocky Mountains in great masses. These masses pushed outward from their centers, especially southward, until a point was reached where the ice melted as rapidly as it advanced. As the ice advanced it buried everything, even the highest mountains, in its path. It would then recede slowly, and apparently normal conditions would be restored for a long period, after which another advance would occur. At least six of these great ice movements took place, each of which covered part of northern United States, altho the same parts were not covered during each ice advance.

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

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

Only four of the great glacial advances actually entered the area that now constitutes Grundy county. The first of these was the Illinoisan glacier, which covered the entire county. A later advance, the Iowan, probably invaded this county, but it is practically impossible to tell to what extent because the deposit which it left was buried by a subsequent glacier, the early Wisconsin. A later ice invasion, the late Wisconsin, occurred in this part of the state but touched only the northeastern part of Grundy county. It is very probable that the extensive sand and gravel deposits of the county were made during the melting of this last glacier.

The thickness of the glacial drift deposit in Grundy county varies from a few feet to as much as 140 feet, but the average thickness is probably not more than 75 or 80 feet. Sometimes in sinking wells, old soils are encountered which represent interglacial periods when normal conditions, so to speak, recurred.

The various agencies that have been at work in the transformation of soil material since the Glacial period necessarily have given the soils of the county a rather varied character.

It should be understood that the glacial drift itself makes up but a very small proportion of the actual soil material in this county, for after the Glacial period this region was covered by a stratum of wind-blown material called loess, which now varies from two to five feet in thickness. The loess constitutes a very large part of the present soil material. On the steeper slopes where considerable erosion has taken place, the drift may form part of the subsoil or even part of the subsurface and surface soil. As a rule, the loess provides better material for the formation of soils than does the glacial drift.

During the melting of the late Wisconsin glacier, the Illinois river swept over a large part of the extensive terrace region lying at the north of Mazonia and deposited there a considerable amount of sand and gravel, thus giving rise to a large area of sandy soils.

A glacial lake known as Glacial Lake Morris once covered a large portion of Grundy county and no doubt was an important factor in the formation of soil over the area which it covered. It was responsible for the heavy Black Clay Loam and also for those soils with heavy and tight subsoils, such as Brown-Gray Clay Loam On Tight Clay (1122.1) and Brown Silt Loam On Tight Clay (1128.1), as well as for the heavier subsoil of Brown Silt Loam (1126).

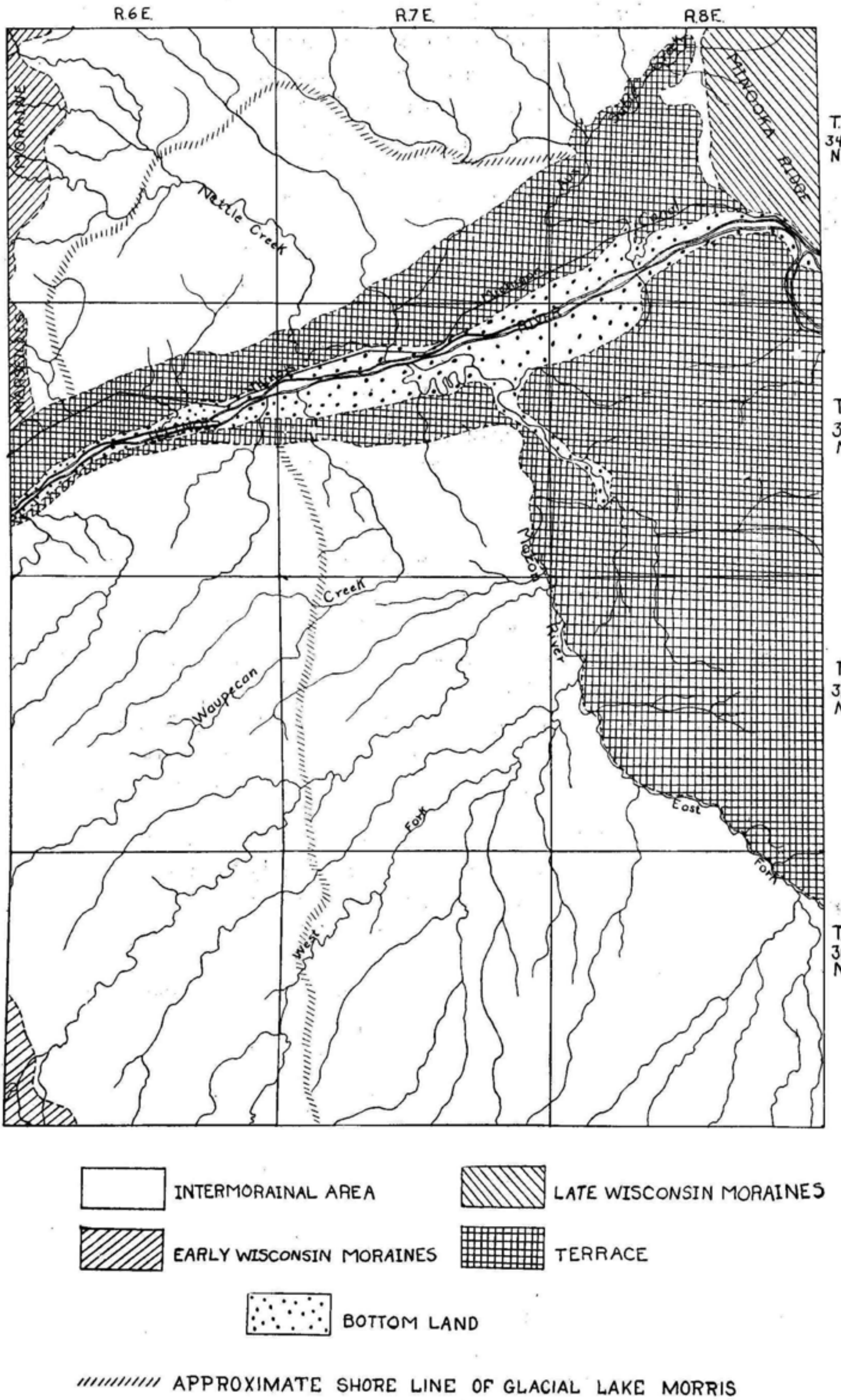
Besides these various agencies influencing the formation of the soils of this area, there has been another important factor. The topography, or natural lay of the land, has had much to do in bringing about the great variations now found in the accumulation of organic matter in these soils.

PHYSIOGRAPHY AND DRAINAGE

The surface of Grundy county forms an extensive rolling plain with a depression extending east and west thru which the Illinois river flows. The variation in topography is due to three agencies: first, and most important, to the more or less uniform deposition of material by glaciers, which resulted in the preservation of some of the pre-glacial irregularities; second, to postglacial erosion and deposition by streams, by which valleys were produced; third, to the transportation and deposition of sand by the wind. The greatest variation in topography is found in the northeast part of the county, where the range of altitude is 150 feet or more between the bottom land of the Illinois river and the crest of the Minooka ridge.

The Illinois river flows thru the county in a southwest direction, while nearly all the lesser streams both north and south of the Illinois flow southeast or northeast. This is due to the fact that the Marseilles moraine, which lies mainly over the line in LaSalle and Livingston counties, imparts an eastward slope to the land for some distance from the edge of the moraine. The principal streams draining the part of the county north of the Illinois river are Nettle and Aux Sable creeks. The principal streams south of the Illinois are Mazon river, with its several tributaries, Waupecan creek, Bills run, and Hog run.

The territory of Grundy county, at the close of the Glacial period, was largely covered by Glacial Lake Morris which left a large area of swamp land, as is indicated by the present extensive areas of Black Clay Loam. The terrace area in the county was also originally poorly drained. Artificial drainage, how-



MAP SHOWING THE DRAINAGE BASINS OF GRUNDY COUNTY WITH MORAINAL, INTERMORAINAL, TERRACE, AND BOTTOM-LAND AREAS ever, has been sufficiently provided so that the county as a whole is now fairly well drained, and practically all of the land is under cultivation.

The altitudes of some places in Grundy county are as follows: Braceville, 590 feet; Dell Abbey, 549; Divine, 525; Gardner, 590; Mazon, 592; Minooka, 632; Morris, 504; Nettle Creek, 648; Sand Ridge, 545; Stockdale, 522. Minooka Ridge reaches an altitude of about 635 feet. The drop to the Illinois river is very sudden, low water on the east county line being 490 feet. The highest point in the county is 710 feet in the northwest corner; the lowest, 465 feet, at low water in the Illinois river where it leaves the county. The southwest corner of the county has an altitude of 687 feet.

SOIL TYPES

The soils of Grundy county are classified under 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 caused the accumulation of 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 Grundy county, classified according to the groups described above. It also shows the area of each type in square miles and in acres, and its percentage of the total area of the county.

TABLE 1.—SOIL TYPES OF GRUNDY COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(a) Upland Prairie Soils (900, 1000, 1100)			
926, 1026, 1126	Brown Silt Loam	168.27	107,693	39.36
920, 1020, 1120	Black Clay Loam	95.07	60,845	22.24
1060, 1160	Brown Sandy Loam	17.49	11,193	4.09
1128.1	Brown Silt Loam On Tight Clay	1.32	845	.31
1128	Brown-Gray Silt Loam On Tight Clay	.73	467	.17
1168	Brown-Gray Sandy Loam On Tight Clay	.31	198	.07
1122.1	Brown-Gray Clay Loam On Tight Clay	1.02	653	.24
1160.4	Brown Sandy Loam On Gravel	.05	32	.01
		284.26	181,926	66.49

TABLE 1.—SOIL TYPES OF GRUNDY COUNTY, ILLINOIS, *Concluded*

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	(b) Upland Timber Soils (900, 1000, 1100)			
934, 1034, 1134	Yellow-Gray Silt Loam	7.65	4,896	1.79
935, 1035, 1135	Yellow Silt Loam	4.28	2,739	1.00
1064, 1164	Yellow-Gray Sandy Loam	.80	512	.19
1181	Dune Sand	.08	51	.02
		12.81	8,198	3.00
	(c) Terrace Soils (1500)			
1526	Brown Silt Loam	17.82	11,405	4.17
1520	Black Clay Loam	10.55	6,752	2.47
1560	Brown Sandy Loam	49.45	31,648	11.57
1534	Yellow-Gray Silt Loam	2.56	1,638	.60
1564	Yellow-Gray Sandy Loam	2.09	1,338	.49
1528	Brown-Gray Silt Loam On Tight Clay	.32	205	.08
1568	Brown-Gray Sandy Loam On Tight Clay	.21	134	.05
1581	Dune Sand	6.62	4,237	1.55
1561	Black Sandy Loam	1.07	685	.25
1560.5	Brown Sandy Loam On Rock	1.47	941	.34
1526.5	Brown Silt Loam On Rock	1.78	1,139	.42
1566	Brown Sandy Loam Over Gravel	1.06	678	.24
1564.4	Yellow-Gray Sandy Loam On Gravel	.10	64	.02
1560.4	Brown Sandy Loam On Gravel	2.80	1,792	.65
		97.90	62,656	22.90
	(d) Swamp and Bottom-Land Soils (1400)			
1426	Deep Brown Silt Loam	13.40	8,576	3.14
1454	Mixed Loam	7.27	4,653	1.70
1420	Black Clay Loam	.45	288	.11
1460	Brown Sandy Loam	3.77	2,413	.85
1450	Black Mixed Loam	1.62	1,037	.39
1410	Peaty Loam On Clay	.15	96	.03
1402	Medium Peat On Clay	.14	90	.03
1401	Deep Peat	.38	243	.09
1413	Muck On Clay	.18	115	.05
1413.6	Muck On Marl	.01	6	.002
		27.37	17,517	6.40
	(e) Residual Soils			
060.5	Brown-Sandy Loam On Rock	1.34	857	.31
064.5	Yellow-Gray Sandy Loam On Rock	.20	128	.05
099	Rock Outcrop	.02	13	.004
		1.56	998	.36
	(f) Miscellaneous			
	Water	3.22	2,061	.76
	Mine Dumps	.30	192	.07
	Swamp	.12	77	.02
		3.64	2,330	.85
	Total	427.54	273,625	100.00

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

INVOICE OF THE ELEMENTS OF PLANT FOOD IN GRUNDY COUNTY SOILS

In order to obtain a knowledge of its chemical composition, each soil type is sampled in the manner described below and subjected to chemical analysis for its important plant-food elements. For this purpose samples are taken usually in sets of three to represent different strata in the top 40 inches of soil; namely, an upper stratum (0 to 6⅔ inches), a middle stratum (6⅔ to 20 inches), and a lower stratum (20 to 40 inches). These sampling strata correspond approximately in the common kinds of soil to 2,000,000 pounds per acre of dry soil in the upper stratum, and to two times and three times this quantity in the middle and lower strata respectively. This, of course, is a purely arbitrary division of the soil section, very useful in arriving at a knowledge of the quantity and distribution of the elements of plant food in the soil, but it should be borne in mind that these strata seldom coincide with the natural strata as they actually exist in the soil and which are referred to in describing the soil types as surface, subsurface, and subsoil. By this system of sampling we have represented separately three zones for plant feeding. The upper, or surface layer, includes at least as much soil as is ordinarily turned with the plow, and this is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated.

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 from their insoluble forms is governed by many factors.

For convenience in making application of the chemical analyses, the results as presented here have been translated from the percentage basis and are given in the accompanying tables in terms of pounds per acre. In this, the assumption is made that for ordinary types a stratum of dry soil of the area of an acre and 6⅔ inches thick weighs 2,000,000 pounds, exceptions being made of certain soils very high in organic matter, such as the peats and the mucks. It is understood, of course, that this value is only an approximation but it is believed that, with this understanding, 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 UPPER SAMPLING STRATUM

In Table 2 are reported the amount of organic carbon (which serves as a measure of the total organic matter), and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in 2 million pounds of the surface soil of each type in Grundy county.

Because of the extreme variations frequently found within a given soil type with respect to the presence of limestone and acidity in the different strata, no attempt is made to include in the tabulated results figures purporting to represent their averages in the respective types. In examining each soil type, however, qualitative tests are made which furnish general information regarding the soil reaction, and in the discussions of the individual soil types which follow, recommendations based upon these tests are given concerning the lime requirement of the respective types. Such recommendations cannot be made specific in all cases because local variations exist, and because the lime requirement may change from time to time, especially under cropping. Therefore it is often desirable to determine the lime requirement for a given field and in this connection the reader is referred to the section in the Appendix dealing with the application of limestone (page 43).

In looking over Table 2 it is of interest to note the marked variation among the different soil types with respect to the content of the various plant-food elements. For example, observing the variation in nitrogen it may be noted that the type, Medium Peat On Clay, contains in the plowed soil of an acre about 28 times as much nitrogen as Dune Sand, Terrace. Comparing this same type, Medium Peat On Clay, with the commonest type in the county, Brown Silt Loam, we find that the former contains nearly four times as much nitrogen as the latter while with respect to potassium the position is exactly reversed, the latter containing nearly four times as much potassium as the former. The supply of phosphorus in the surface layer varies from 540 pounds per acre in Dune Sand, Terrace, to 2240 pounds per acre in Brown Silt Loam On Rock, Terrace. A sulfur content of only 160 pounds per acre is found in the Dune Sand, while in an equal volume of Medium Peat On Clay the analysis shows more than 5000 pounds of this element. In like manner the magnesium varies in the different types from 2,100 to more than 17,000 pounds, and the calcium content ranges from less than 3,000 pounds, to nearly 30,000 pounds per acre.

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded in a similar manner the amounts of the plant-food elements in the middle and lower sampling strata. It is frequently of interest to know the total supply of a plant-food element accessible to the growing crops. While it is impracticable to obtain this information exactly, because of the variation in root growth, it may be assumed that the bulk of the feeding range of the roots of most of our common field crops is included in the upper 40 inches of soil. By adding together for a given soil type the corresponding figures in Tables 2, 3, and 4, the total amounts of the respective plant-food elements to a depth of 40 inches may be ascertained.

A wide range of variation with respect to composition is found to occur in the sub-layers as well as in the top layer of the various soil types. The tables reveal further that there is not only this wide diversity among the different soils with respect to a given plant-food element, but that there is also a great variation with respect to the relative abundance of various elements within a given soil type as measured by crop requirements. For example, in the commonest type in the county, Brown Silt Loam, we find that the total quantity of nitrogen in an acre to a depth of 40 inches amounts to 16,180 pounds. This is about the amount of nitrogen contained in 16,000 bushels of corn. On the other hand there is present in the same quantity of this soil 251,970 pounds of potassium, or the equivalent of that contained in nearly 1⅓ million bushels of corn.

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF GRUNDY COUNTY, ILLINOIS
UPPER SAMPLING STRATUM: ABOUT 0 TO 6⅔ INCHES

Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (1000, 1100)							
1026 1126	Brown Silt Loam	72 080	5 670	1 070	1 230	37 000	8 370	11 200
1120	Black Clay Loam	78 960	6 840	1 580	1 340	36 420	11 860	29 890
1160	Brown Sandy Loam	63 990	5 020	1 130	1 200	27 080	6 560	18 690
1128.1	Brown Silt Loam On Tight Clay	50 800	4 380	940	760	39 940	7 480	8 360
1128	Brown-Gray Silt Loam On Tight Clay	44 740	3 860	1 020	920	36 600	5 880	8 740
1168	Brown-Gray Sandy Loam On Tight Clay	35 860	3 000	740	500	19 400	2 940	5 260
1122.1	Brown Gray Clay Loam On Tight Clay	59 900	4 960	940	1 040	43 360	11 160	11 920
1160.4	Brown Sandy Loam On Gravel	53 820	4 620	1 500	1 480	25 620	6 260	10 680
	(b) Upland Timber Soils (1000, 1100)							
1034 1134	Yellow-Gray Silt Loam	31 960	2 630	780	730	36 860	5 690	10 940
1135	Yellow Silt Loam	26 500	2 360	580	720	41 560	8 120	7 040
1164	Yellow-Gray Sandy Loam	22 980	1 800	720	480	29 200	4 880	5 830
1181	Dune Sand	15 680	1 080	520	420	21 080	2 100	6 700
	(c) Terrace Soils (1500)							
1526	Brown Silt Loam	77 150	6 540	1 500	1 380	38 310	11 900	19 950
1520	Black Clay Loam	76 950	6 300	1 480	1 550	51 250	17 120	18 180
1560	Brown Sandy Loam	59 870	5 700	930	980	21 750	4 910	15 930
1534	Yellow-Gray Silt Loam	31 620	2 460	880	700	37 620	5 660	8 200
1564	Yellow-Gray Sandy Loam	21 740	1 760	560	340	27 860	3 920	7 000
1528	Brown-Gray Silt Loam On Tight Clay	49 860	4 640	920	680	44 200	11 360	8 680
1568	Brown-Gray Sandy Loam On Tight Clay	29 360	4 440	920	780	17 860	2 700	6 400
1581	Dune Sand	12 520	770	540	160	21 470	2 740	5 460
1561	Black Sandy Loam	64 600	5 520	1 140	1 140	28 280	7 320	14 020
1560.5	Brown Sandy Loam On Rock	80 000	6 300	1 280	1 400	25 600	3 540	3 600
1526.5	Brown Silt Loam On Rock	111 180	9 180	2 240	1 780	40 920	11 900	17 260
1566	Brown Sandy Loam Over Gravel	22 260	2 240	900	400	26 400	4 500	5 920
1564.4	Yellow-Gray Sandy Loam On Gravel	19 420	1 540	920	400	23 900	4 460	9 380
1560.4	Brown Sandy Loam On Gravel	33 220	2 660	1 500	580	27 340	6 580	9 960

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF GRUNDY COUNTY, ILLINOIS, *Concluded*

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phos-phorus	Total sulfur	Total potas-sium	Total magne-sium	Total calcium
	(d) Late Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	72 350	6 380	1 060	1 090	48 940	16 950	22 070
1454	Mixed Loam[1]							
1420	Black Clay Loam	87 560	7 860	1 780	1 420	43 920	14 380	18 760
1460	Brown Sandy Loam	49 780	4 280	980	700	30 260	5 260	8 700
1450	Black Mixed Loam[1]							
1410	Peaty Loam On Clay[3]	197 930	15 680	1 290	2 610	18 230	5 720	18 000
1402	Medium Peat On Clay[2]	264 800	21 380	970	5 280	9 820	7 160	21 460
1401	Deep Peat[2]	175 810	13 040	1 120	2 380	9 410	3 720	12 740
1413	Muck On Clay[3]	117 680	9 350	1 590	1 280	33 410	10 040	14 570
1413.6	Muck On Marl[3]	72 150	9 530	1 020	1 140	22 400	8 360	21 330
	(e) Residual Soils (000)							
060.5	Brown Sandy Loam On Rock	74 680	6 240	1 140	1 040	21 040	3 180	2 320
064.5	Yellow-Gray Sandy Loam On Rock	26 720	3 120	980	940	26 500	5 140	3 140
099	Rock Outcrop							

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 the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]On account of the heterogeneous character of Mixed Loam and Black Mixed Loam chemical analyses are not included for these types.
[2]Amounts reported are for 1 million pounds.
[3]Amounts reported are for 1½ million pounds.

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF GRUNDY COUNTY, ILLINOIS
MIDDLE SAMPLING STRATUM: ABOUT 6⅔ TO 20 INCHES
Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (1000, 1100)							
1026 1126	Brown Silt Loam	80 200	7 190	1 670	1 600	76 140	21 470	21 460
1120	Black Clay Loam	65 110	5 960	2 430	1 610	76 460	21 730	34 120
1160	Brown Sandy Loam	62 180	5 640	1 800	1 620	56 320	14 620	20 520
1128.1	Brown Silt Loam On Tight Clay	48 400	4 480	1 200	1 040	83 160	23 800	13 920
1128	Brown-Gray Silt Loam On Tight Clay	48 640	4 200	1 760	1 400	74 720	16 360	16 560
1168	Brown-Gray Sandy Loam On Tight Clay	24 080	1 720	920	520	39 520	6 080	9 160
1122.1	Brown-Gray Clay Loam On Tight Clay	58 360	5 320	1 280	1 600	94 680	29 800	20 680
1160.4	Brown Sandy Loam On Gravel	77 800	4 760	2 240	1 920	50 560	40 440	71 200
	(b) Upland Timber Soils (1000, 1100)							
1034 1134	Yellow-Gray Silt Loam	24 460	2 300	1 560	980	75 500	16 480	20 160
1135	Yellow Silt Loam	27 200	3 080	1 320	1 360	134 000	49 520	30 760
1164	Yellow-Gray Sandy Loam	19 440	1 560	1 240	680	61 480	11 760	7 280
1181	Dune Sand	28 680	1 720	840	720	42 240	5 120	1 480
	(c) Terrace Soils (1500)							
1526	Brown Silt Loam	67 380	6 040	1 940	1 720	79 280	53 240	81 500
1520	Black Clay Loam	74 440	6 920	2 320	1 520	100 900	39 500	41 760
1560	Brown Sandy Loam	28 360	2 720	1 150	560	45 930	8 840	19 710
1534	Yellow-Gray Silt Loam	32 760	2 560	1 480	1 120	78 400	15 480	15 920
1564	Yellow-Gray Sandy Loam	15 600	1 400	1 080	920	67 040	22 000	21 520
1528	Brown-Gray Silt Loam On Tight Clay	39 640	4 480	1 040	840	105 680	35 160	14 920
1568	Brown-Gray Sandy Loam On Tight Clay	41 080	2 920	1 080	640	40 680	6 240	12 000
1581	Dune Sand	10 640	720	960	120	44 220	6 000	11 020
1561	Black Sandy Loam	46 880	3 880	1 360	880	58 640	13 680	23 040
1560.5	Brown Sandy Loam On Rock	38 600	3 120	1 120	1 520	60 240	3 560	28 080
1526.5	Brown Silt Loam On Rock	127 400	11 040	3 600	2 560	87 920	27 520	57 440
1566	Brown Sandy Loam Over Gravel	43 680	3 400	1 640	560	57 680	10 760	13 320
1564.4	Yellow-Gray Sandy Loam On Gravel	22 880	1 560	1 320	440	44 480	11 400	21 680
1560.4	Brown Sandy Loam On Gravel	53 800	4 440	2 800	1 240	54 920	15 000	22 400

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF GRUNDY COUNTY, ILLINOIS, *Concluded*

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(d) Late Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	102 360	9 980	3 080	1 720	95 180	28 640	37 320
1454	Mixed Loam[1]							
1420	Black Clay Loam	91 960	8 560	2 240	1 480	81 920	22 120	29 680
1460	Brown Sandy Loam	52 840	4 080	1 480	640	59 800	8 560	14 440
1450	Black Mixed Loam[1]							
1410	Peaty Loam On Clay[3]	332 670	26 760	1 740	4 560	42 390	11 490	31 380
1402	Medium Peat On Clay[2]	343 540	28 900	880	8 600	30 040	11 980	41 180
1401	Deep Peat[2]	378 420	30 000	1 860	5 420	17 160	10 840	37 720
1413	Muck On Clay	222 120	18 240	3 240	2 000	84 560	27 480	34 320
1413.6	Muck On Marl	78 080	7 520	1 960	2 320	51 800	23 320	183 200
	(e) Residual Soils (000)							
060.5	Brown Sandy Loam On Rock	31 680	2 680	1 080	1 040	53 520	8 440	6 120
064.5	Yellow-Gray Sandy Loam On Rock	20 480	1 840	1 400	600	56 480	6 960	4 600
099	Rock Outcrop							

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

[1]On account of the heterogeneous character of Mixed Loam and Black Mixed Loam chemical analyses are not included for these types.
[2]Amounts reported are for 2 million pounds.
[3]Amounts reported are for 3 million pounds.

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF GRUNDY COUNTY, ILLINOIS
LOWER SAMPLING STRATUM: ABOUT 20 TO 40 INCHES

Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(a) Upland Prairie Soils (1000, 1100)							
1026 1126	Brown Silt Loam	35 730	3 320	1 890	1 440	138 830	67 490	105 720
1120	Black Clay Loam	34 270	3 170	3 060	1 320	124 620	59 900	76 500
1160	Brown Sandy Loam	27 900	2 250	2 010	1 320	95 430	38 550	48 450
1128.1	Brown Silt Loam On Tight Clay	29 940	3 540	1 920	1 320	153 060	58 800	30 900
1128	Brown-Gray Silt Loam On Tight Clay	37 620	3 480	2 220	1 560	145 980	69 000	76 440
1168	Brown-Gray Sandy Loam On Tight Clay	26 700	1 920	1 260	480	66 300	16 560	17 220
1122.1	Brown-Gray Clay Loam On Tight Clay	31 380	3 180	2 160	16 680	149 520	57 300	53 940
	(b) Upland Timber Soils (1000, 1100)							
1034 1134	Yellow-Gray Silt Loam	29 700	2 640	2 730	1 500	116 250	88 290	159 510
1135	Yellow Silt Loam	35 160	3 660	2 040	2 100	200 220	176 520	222 660
1164	Yellow-Gray Sandy Loam	26 220	2 340	2 280	960	95 220	32 100	39 240
1181	Dune Sand	26 460	1 380	900	600	63 960	7 680	6 180
	(c) Terrace Soils (1500)							
1526	Brown Silt Loam	34 170	3 030	2 500	1 680	126 870	149 970	180 960
1520	Black Clay Loam	56 790	4 710	2 700	1 800	142 470	128 580	184 470
1560	Brown Sandy Loam	16 220	1 180	1 100	520	64 740	16 700	49 220
1534	Yellow-Gray Silt Loam	46 080	3 120	2 580	1 440	105 840	155 520	243 540
1564	Yellow-Gray Sandy Loam	14 940	1 200	960	1 080	89 340	21 000	18 300
1528	Brown-Gray Silt Loam On Tight Clay	20 580	3 540	1 620	1 740	170 340	65 880	25 320
1568	Brown-Gray Sandy Loam On Tight Clay	20 520	1 740	720	840	63 900	12 660	19 140
1581	Dune Sand	10 830	540	1 530	390	64 350	7 650	17 220
1561	Black Sandy Loam	16 680	1 560	1 080	1 020	86 280	11 640	25 560
1566	Brown Sandy Loam Over Gravel	34 380	2 760	2 400	720	91 500	22 620	20 880

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF GRUNDY COUNTY, ILLINOIS, *Concluded*

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	(d) Late Swamp and Bottom-Land Soils (1400)							
1426	Deep Brown Silt Loam	90 180	8 280	3 390	1 980	141 750	48 390	52 830
1454	Mixed Loam[1]							
1420	Black Clay Loam	72 300	6 540	4 560	1 620	125 040	30 720	46 920
1460	Brown Sandy Loam	42 420	1 980	1 260	420	77 760	10 020	20 460
1450	Black Mixed Loam[1]							
1410	Peaty Loam On Clay[3]	252 770	17 100	1 800	10 530	81 000	23 400	43 160
1402	Medium Peat On Clay[2]	256 500	18 180	1 080	30 180	58 800	32 580	124 500
1401	Deep Peat[4]	280 650	23 340	1 950	5 730	28 080	10 470	30 930
1413	Muck On Clay	234 900	16 500	3 420	2 280	141 420	45 420	44 640
1413.6	Muck On Marl	35 160	3 120	1 980	1 860	52 620	67 080	1 051 560

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

[1]On account of the heterogeneous character of Mixed Loam and Black Mixed Loam chemical analyses are not included for these types.
[2]Amounts reported are for 3 million pounds.
[3]Amounts reported are for 4½ million pounds.

These statements are not intended to imply that it is possible to predict how long it might be before a certain soil would become exhausted under a given system of cropping. Neither do the figures necessarily indicate the immediate procedure to be followed in the improvement of a soil, for other factors enter into consideration aside from the mere amount of plant-food elements present in the soil. Much depends upon the nature of the crops to be grown as to their utilization of plant food, and much depends upon the condition of the plant-food substances themselves as to their availability. Finally in planning the detailed procedure for the improvement of a soil, there enter for consideration all the economic factors involved in any fertilizer treatment. Such figures do, however, furnish an inventory of the total stocks of plant-food elements that can possibly be drawn upon and in this way these chemical data contribute fundamental information for the intelligent planning in a broad way of systems of soil management for conserving and improving the fertility of the land.

DESCRIPTION OF INDIVIDUAL SOIL TYPES

(a) UPLAND PRAIRIE SOILS

The upland prairie soils of Grundy county cover 284.26 square miles, or two-thirds of the area of the county. Owing to the accumulation of organic matter, derived very largely from the roots of the prairie grasses that once covered the land, the soils of this group are dark in color, varying from dark brown to black. The network of comparatively thick roots of these grasses was protected from complete decomposition by imperfect aeration resulting from the covering of fine, moist soil material. The flat prairie contains a higher amount of organic matter than the more rolling land because the grasses grew more luxuriantly there and the higher moisture content retarded the decay of their roots. The material resulting from this partial decomposition is a black substance of varying chemical composition. Some of it has probably been in the soil for many thousands of years and has reached a stage similar to coal. It is almost wholly resistant to decay. This old organic matter, as well as that more recently formed, gives a dark color to the soil.

The upland prairie soils in this county include some areas of recent timber growth, where certain kinds of trees have invaded the prairie but have not grown for a long enough time to produce the characteristic timber soil. These areas are usually narrow and are found along the border of most timber tracts. In consulting the map, therefore, one should have in mind the fact that the timber may actually extend a little farther than the soil type would appear to indicate.

Brown Silt Loam (926, 1026, 1126)

Brown Silt Loam is the most extensive soil type in Grundy county. It varies considerably in different portions of the county in depth, color, texture, topography and composition. Rolling morainal areas occur in the northeast, northwest, and southwest corners of the county. In these areas the tops and slopes of the ridges are of a shallower and lighter colored soil than is found in the low, more nearly flat areas, and the glacial till is frequently found 30 inches or less from the surface. The Brown Silt Loam bordering the sandy terrace is generally a sandy phase of silt loam and contains areas of sandy loam which are too small to be shown on the map. The remainder of the Brown Silt Loam area in the county is flat to gently undulating in topography, and generally heavier and deeper than is normal for the type. Tile drainage is common thruout the more level portions.

The following description applies to this type as it has been found to occur in Grundy county. The surface soil varies in depth from 9 to 12 inches, in color from a brownish black to a light brown, and in texture from a sandy silt loam to a heavy or clayey silt loam. This stratum is fairly well supplied with organic matter; however, it is not at all uncommon for the amount of fresh, active organic matter to be reduced to a point where the tilth of the soil is unfavorably affected. The subsurface, which extends to a depth of 17 to 28 inches, varies from a grayish brown to a mottled, light yellowish silt loam to silty clay loam. The subsoil is a fairly compact, but pervious, mottled, yellow clay to a depth of 34 to 40 inches, where it passes into a more friable and usually a grayer and more strongly mottled clay loam. Strong effervescence with acid shows the presence of limestone at a depth of 30 to 40 inches.

Management.—The first essential in the management of the type is to install drainage where needed. The next step is to apply ground limestone when tests show the soil to be acid. A large portion of the area covered by this type is not yet in need of limestone in the surface, and carbonate of lime is uniformly found in the subsoil at a depth of 30 to 45 inches. The higher, more rolling areas are acid in the surface, tho not strongly so, and it is recommended that about two tons of ground limestone per acre be applied to these areas. With the drainage and the need for lime provided for, the way is open for taking care of the organic-matter and nitrogen needs of the soil.

Brown Silt Loam, when it is first brought under cultivation, is rich in fresh organic matter and good tilth is easily maintained. Continuous cropping, with its inevitable destruction of organic matter, has in many cases resulted in such a depletion of this important soil material that a condition of poor tilth has followed. It is probably unnecessary to keep the organic-matter content of this type at its original high level, but provision should be made for returning sufficient fresh organic matter so that a reasonable amount of tillage will produce a condition of good tilth. Such a condition cannot be maintained without the frequent plowing down of fresh organic matter such as crop residues, barnyard manure, catch crops, and, if necessary, entire legume crops. The fact that this soil is dark brown or black in color does not mean that it is sufficiently supplied with organic matter. The dark color is largely imparted by the well-decayed, resistant, black colored portions of the organic matter, and these portions have comparatively little value, either chemical or physical. Another reason of prime importance for making full use of all the sources of organic matter, particularly of leguminous plants, is to secure and conserve the nitrogen supply. Red and alsike clover will grow fairly satisfactorily on this type without the use of lime, excepting on the more rolling portions. Alfalfa and sweet clover, however, will usually not do well until the land has been limed, particularly on the higher areas.

The evidence regarding the use of phosphate fertilizers on this type is not entirely satisfactory. The experiment field results indicate that either steamed bone meal or rock phosphate can be used at a profit on the higher, lighter colored areas. They also indicate that it is doubtful whether rock phosphate can be used profitably on the heavier areas. No information is available as to whether steamed bone meal can be profitably used on the heavier areas. If rock phosphate is used, it should be applied with organic matter at the rate of about half a ton per acre every four or five years. If one of the soluble forms of phosphate is used, it should be applied in amounts sufficient to compensate for that removed by crops, and preferably on the wheat. See discussion of the phosphorus problem in the Appendix, page 45.

If grain farming is practiced, the rotation may be wheat, corn, oats, and clover, with an extra seeding of clover (preferably sweet clover) as a catch crop in the wheat, to be plowed under for corn the following year. The crop residues, with the possible exception of wheat and oat straw, including the clover chaff from the seed crops, should be plowed under. In live-stock farming, the regular rotation may be extended to five or six years by seeding both timothy and clover with the oats, and pasturing one or two years. Alsike may well replace red clover at times, and the value of sweet clover is well recognized in this county. In either system, grain or live-stock, alfalfa may be grown on a fifth field, moving to another field at the end of a rotation, or it may be used in the regular rotation in place of all or a part of the clover. For other suggestions concerning crop rotations, the reader is referred to the Appendix, page 50. The results of field experiments on Brown Silt Loam are given in the Supplement, page 54.

Black Clay Loam (920, 1020, 1120)

Black Clay Loam is one of the flat, heavy, prairie-land types. It is sometimes called "gumbo," because of its sticky character. Its formation 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 slightly higher adjoining lands, or to deposition from the slowly moving water of a lake or a swamp. This type in Grundy county occurs to a very large extent within the limits of Glacial Lake Morris, both north and south of the Illinois river (see drainage map). Numerous streams were responsible for carrying and depositing the fine sediment entering into the formation of the soils on the lake bed. This type occupies 95.07 square miles, or more than one-fifth of the area of the county.

The surface soil is a black, granular, clay loam of medium plasticity to a depth of about 9 inches. It is well supplied with total organic matter, but is generally becoming deficient in active or easily decomposable organic materials. The subsurface extends to a depth of 19 to 27 inches, and is a yellowish or brownish drab clay loam. Considerable variation in color is found in the subsurface indicating differences in drainage. The subsoil to a depth of 36 to 40 inches is a mottled yellow, or mottled drab clay, usually not readily permeated by water, owing to compaction. As a rule, strong effervescence with an acid is found at about 36 inches, showing the presence of large amounts of carbonate of lime.

Management.—The most important consideration in the management of this type is to maintain good tilth. This condition is promoted by providing good underdrainage and maintaining the supply of fresh organic matter by the use of crop residues, legume catch crops, and green manures. Numerous tests show that it is not necessary to apply limestone, as the surface soil is neutral or alkaline and carbonates always occur in the subsoil.

While Black Clay Loam is one of the best soils in the state, yet its fine texture gives it the property of shrinkage and expansion to such a degree as to be somewhat objectionable at times, especially during drouth. When the soil is wet, it expands, and when the moisture evaporates or is used by the crops, it shrinks. This results in the formation of cracks which extend two or three feet in depth and which are sometimes two or more inches wide at the surface. These cracks allow the soil to dry out rapidly, and as a result the crop is injured thru lack of moisture. They may do considerable damage by "blocking out" hills of corn and severing the roots. While cracking may not be prevented entirely, good tilth and a soil mulch will do much toward that end. Cultivation is more essential on this heavy type than on the lighter types of soil. It must be remembered, however, that cultivation should be as shallow as possible in order to avoid injuring the roots of the cultivated crop.

Brown Sandy Loam (1060, 1160)

The mixed wind and water origin of Brown Sandy Loam has resulted in a great variation in the type. The area found in the southwest corner of Good Farm township (Township 31 North, Range 7 East) is heavier and naturally more poorly drained than that which occurs as a belt bordering the sandy terrace. The color varies from a light brown on the sandier dune-like portions to dark brown or black on the lower, heavier areas. Wide variations in the chemical composition of the type, as well as in its physical properties, are shown by the analyses of samples collected to represent the type.

The surface soil, which is 8 to 10 inches deep, is predominantly a brown sandy loam. The low ridges or dune-like formations are lighter in color and coarser in texture and the flat areas, particularly in Good Farm township, are dark brown to black and contain enough silt and clay to make the soil a heavy phase of sandy loam. The subsurface, which extends to a depth of 20 to 22 inches, is a fairly distinct stratum of grayish brown to gray sandy loam or clayey sand in the more poorly drained areas, becoming mottled yellow where the drainage is better. The subsoil begins at a depth of 20 to 22 inches. It is a gray to mottled yellow sandy clay, rather compact, and passes into gray sand or mottled yellow till at 30 to 45 inches in depth.

Management.—No specific recommendations can be given for the management of this type as a whole, because of the wide variations found to exist. In general, the lighter colored areas require the application of about 2 tons of limestone per acre in order to grow alfalfa or sweet clover, while the low flat areas need no lime.

The coarse texture of the sandier phases of the type makes it difficult to maintain organic matter because of rapid decay resulting from too much aeration. Cowpeas and soybeans can be grown successfully on these sandier areas without limestone, while sweet clover, which is an important crop in Grundy county, does well if limestone is used. Alfalfa is also a good crop for this kind of land, altho it is more difficult to start on this sandy soil than on heavier soil.

The phosphorus content of the sandier phase of the type is low. No definite information is available as to what form of phosphate can be used at a profit, or whether phosphate in any form can be so used. The best information available indicates that it is very doubtful whether rock phosphate will return a profit on the sandier phases of the type. It is reasonable to suppose that the more soluble forms, either steamed bone meal or acid phosphate, if properly used, will prove profitable and at the same time will maintain or increase the total phosphorus supply in the soil.

As a rule, Brown Sandy Loam is naturally well drained, altho there are areas thruout the type which have poor natural drainage, particularly in Good Farm township.

Brown Silt Loam On Tight Clay (1128.1)

Brown Silt Loam On Tight Clay occurs in small areas in the south central part of the county and in the northeast corner. It resembles Brown Silt Loam in the surface, but the subsoil is very different, in that it is impervious.

The surface soil is a brown silt loam with a grayish tint. It passes into the subsurface, which is a yellowish brown silt loam, at a depth of 9 to 10 inches. The subsoil begins at a depth of 16 to 20 inches. It is a drab clay, strongly mottled with yellow. The subsoil is very plastic and is impervious to air and water.

Management.—Drainage of this type is difficult because of the presence of the impervious subsoil. The type is not strongly acid but for the growth of sweet clover about 2 tons of limestone per acre is recommended.

Brown-Gray Silt Loam On Tight Clay (1128)

Only a few small areas of Brown-Gray Silt Loam On Tight Clay are found in Grundy county. The surface soil is a grayish brown silt loam about 8 inches in depth. The subsurface is a dark grayish or brownish gray silt loam which extends to a depth of about 20 inches. The subsoil is a compact, impervious, mottled, drab clay.

Management.—The management of this type is the same as that suggested for Brown Silt Loam On Tight Clay.

Brown-Gray Sandy Loam On Tight Clay (1168)

Brown-Gray Sandy Loam On Tight Clay is found in the vicinity of the other tight clay types. This type is of minor importance, as there is but little of it in Grundy county.

The surface is a brownish gray sandy loam about 8 inches in depth. The subsurface, which extends to a depth of about 18 inches, is a gray to brownish gray sandy loam. The subsoil is a mottled brownish gray or drab colored, compact, impervious clay.

Management.—An application of limestone at the rate of 2 tons per acre in connection with the growing of sweet clover is recommended. It appears from the chemical data that the type is low in the various elements of plant food. Altho no data from field experiments are at hand, it seems probable that phosphorus in the form of bone meal or acid phosphate would prove beneficial for wheat and that corn would respond to the application of a potassium salt.

Brown-Gray Clay Loam On Tight Clay (1122.1)

An area of about one square mile of Brown-Gray Clay Loam On Tight Clay occurs four miles northwest of Gardner. It is similar to Brown Silt Loam On Tight Clay excepting that it is a clay loam instead of a silt loam. The topography is flat, being very similar to that of Black Clay Loam.

The surface soil is 8 to 12 inches deep. It varies from a brown silty clay loam to a clay loam that, when dry, has a gray appearance. It is fairly well supplied with organic matter. The subsurface soil, found at a depth of about 8 to 12 inches, is 4 to 10 inches thick and varies from a yellowish brown to a grayish brown or drab color. It becomes grayer and more drabbish in color, and heavier in texture, with increasing depth. The subsoil is found at a depth of 12 to 22 inches, and is a drab to grayish yellow, compact clay, very impervious to water. The chemical analysis of the sample collected reveals the unusually high sulfur content of 16,680 pounds per acre in the lower sampling stratum (20 to 40 inches). This is probably due to an accumulation of gypsum.

Management.—The management of this type should be about the same as that recommended for Brown Silt Loam On Tight Clay described above, except that there is even greater necessity for the maintenance of the organic matter to keep the soil in good tilth. This type shows only slight acidity in the surface soil; however, if sweet clover is to be grown, an application of about 2 tons of ground limestone per acre is advised.

Brown Sandy Loam On Gravel (1160.4)

A small area of Brown Sandy Loam On Gravel occurs in the northeastern part of the county along Aux Sable creek. It covers only 32 acres. The surface stratum is 8 to 10 inches deep. It is a brown sandy loam, fairly well supplied with organic matter. The subsurface is of about the same character as the surface stratum, except that it contains some gravel. At a depth of 22 to 26 inches, gravel constitutes the soil material.

Management.—The presence of considerable limestone close to the surface indicates that the application of this material is not necessary. In other particulars, the management should be about the same as that of Brown Sandy Loam (1160). Early maturing crops should be grown on account of the nearness of the gravel to the surface and the consequent liability to summer drouth.

(b) UPLAND TIMBER SOILS

The upland timber soils occur as irregular zones along streams and on or near somewhat steep morainal ridges. They are characterized by a yellowish gray color, due to their low organic-matter content. The deficiency of organic matter has been caused by the long-continued growth of forest trees. After the forest invaded the prairies, two effects were produced: first, the shade from the trees prevented the growth of prairie grasses, the roots of which are mainly responsible for the large organic-matter content in prairie soils; second, the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed completely or were burned by forest fires. Furthermore, the organic matter that had been produced by the prairie grasses became gradually dissipated during the occupation of the land by the trees. As a result, the organic-matter content of the upland timber soils has been reduced until it is decidedly lower than that of the adjacent prairie land. Several generations of trees were necessary to produce the present condition of the soil.

The upland timber soils of Grundy county cover 12.81 square miles, or 3 percent of the entire area of the county.

Yellow-Gray Silt Loam (934, 1034, 1134)

Yellow-Gray Silt Loam occurs in the vicinity of the Illinois river and its tributaries. There is also an area in the northeastern part of the county on the steeper part of the Minooka ridge near the DuPage river. The type covers 7.65 square miles, or 1.79 percent of the area of the county. In topography it is sufficiently rolling for fair surface drainage without much tendency to wash if proper care is taken.

The surface, which is 7 to 8 inches deep, is a yellowish gray to grayish brown, or gray silt loam. The more nearly level areas are gray or grayish brown in color, while the more rolling phase of the type is yellowish-gray or brownish yellow. As the type approaches Brown Silt Loam, it becomes decidedly darker. The organic-matter content is low. The subsurface stratum varies considerably in thickness. On the more rolling parts, it rarely exceeds 5 inches in thickness, while on the more level areas it varies from 8 to 14 inches. It is usually a gray, grayish yellow, or yellow, silt loam, or sandy silt loam. The subsoil, which begins at a depth of 10 to 22 inches, is a mottled yellow sandy clay, silty clay, or clay, somewhat plastic when wet, but friable when only moist. It is pervious to water. The subsoil varies in physical composition even more than does the surface stratum. Frequently boulder clay constitutes part or all of the subsoil. Sometimes sand may be encountered at a depth of 30 to 40 inches. The sand was deposited by the wind previous to the deposition of the loess which constitutes most of the soil material of the upland in Grundy county.

This type drains well except on some of the more level and older forested areas, where a rather compact subsoil has developed that retards the movement of water.

Management.—In the management of Yellow-Gray Silt Loam, it is very necessary to maintain and even to increase the organic-matter content. This is necessary in order to supply nitrogen, to liberate mineral plant foods, to give the soil better tilth, to prevent running together during heavy rains, and to prevent erosion on the more rolling phase. Rotations should be practiced that for a time at least will keep the soil in pasture, clover, or alfalfa, and will reduce the tilled crops to a minimum acreage.

The type in this county varies somewhat with respect to limestone content. In some localities considerable quantities of limestone are found in the lower sampling stratum, while in other places the reaction is distinctly acid. In planning the improvement of this soil, therefore, it is well to apply the acidity tests described in the Appendix, page 44. In case limestone is needed for the growth of legumes, an initial application of 2 to 3 tons of limestone per acre is advised. Subsequent applications of 1 to 2 tons per acre should be made when the need for it begins to be apparent. The surface soil of this type is low in phosphorus; however, the phosphorus content to a depth of 40 inches exceeds that of Brown Silt Loam. Experiment field results indicate that steamed bone meal can be used at a profit on the type. The use of acid phosphate would also be expected to be profitable. While no experiment field results with rock phosphate which are applicable to this type in Grundy county are available, it is reasonable to suppose that the use of this material, if properly applied, would prove profitable. (See account of Antioch experiment field in the Supplement, page 63.)

Yellow Silt Loam (935, 1035, 1135)

Yellow Silt Loam is an unimportant type in Grundy county because of its small area. There are only 4.28 square miles in the entire county.

The character of this type varies greatly, owing to differences in rate of erosion which are caused chiefly by differences in slope. The surface soil is usually a yellow or grayish silt loam. It may be a yellow clay or even gravel, depending on the amount of erosion. Till is commonly found at 40 inches or less in depth.

Management.—Fortunately but little of this land is under cultivation. It should be kept in permanent pasture or in timber. The surface is usually slightly acid, but carbonate is always found at less than 40 inches, frequently at a depth of 12 to 14 inches. Good pasture may be provided by applying about two tons of limestone per acre and seeding sweet clover. Alfalfa is also a good crop for this land after limestone has been applied.

Yellow-Gray Sandy Loam (1064, 1164)

Five hundred and twelve acres of Yellow-Gray Sandy Loam are found in Grundy county. It occurs, for the most part, along the Mazon river, east and north of Mazon.

The surface is 6 to 7 inches deep and is a grayish yellow sandy loam, low in organic matter. The subsurface, which extends to a depth of 18 to 20 inches, varies in color from gray to yellow and in texture from sand to sandy clay. The subsoil varies from a yellow sand to yellow sandy clay.

Management.—This type is usually slightly acid in the surface, but contains large amounts of carbonate at a depth of 30 to 40 inches. For the growth of legumes, 2 tons of limestone per acre should be sufficient for the initial application. Presumably, beneficial results would be obtained from the application of bone meal or of acid phosphate.

Dune Sand (1181)

There are only 51 acres of Dune Sand of the upland in Grundy county. Its origin, character, and management are so similar to Dune Sand of the terrace region that reference is made to that type. (See page 27).

(c) TERRACE SOILS

Terrace soils are formed on terraces or old fills in valleys. The terraces owe their formation generally to the deposition of material from overloaded streams which became greatly enlarged and which flooded the valleys during the melting of the glaciers. Sometimes these valleys were filled almost to the height of the upland. Later the streams cut down thru the fills and developed new bottom lands, or flood plains, at lower levels, leaving part of the old fills as terraces. The lowest and most recently formed bottom land is called first bottom. The higher land no longer flooded (or very rarely, at most) is generally designated as second bottom. Finer material later deposited on the sand and gravel of the fill constitutes the mineral portion of the soil. Along some of the streams the fill seems to have been made almost entirely of fine, silty material.

Brown Silt Loam (1526)

The Brown Silt Loam of the terrace occurs mainly along the north side of the Illinois river, and in the north half of Township 33 North, Range 8 East (Gooselake). South of this only a few small patches are found scattered in the extensive sand area. In topography the type is flat to slightly undulating, the difference in elevation being due very largely to former channels or old bayous that have become partly filled by sediment. This type is not generally underlain by gravel or sand. In the area south of the river, large numbers of boulders are scattered over the land, frequently in such abundance as to make the land of value for pasture only. In many places these boulders have been removed from the fields and piled along fences; thus some excellent farming land has been reclaimed. The area north of the river does not contain so many of these boulders. The total area of the type is 17.82 square miles, or 4.17 percent of the total area of the county.

The surface is 9 to 10 inches deep and varies in color from light brown to black and in texture from a sandy loam to a heavy silt loam. The subsurface extends to a depth of 15 to 20 inches and varies from a yellowish brown silt loam to a yellow, mottled clay loam. The subsoil is usually bright yellow in color and a clay loam or a sandy clay loam in texture. It is not unusual to strike the bed rock at 30 inches and frequently it is encountered at 20 inches over small areas.

Management.—This type varies in regard to acidity. In other respects it is so similar to the Brown Silt Loam of the upland that reference is made to the management recommended for that type (see page 16).

Black Clay Loam (1520)

Black Clay Loam, Terrace, is found principally along the Illinois river, where it is associated with Brown Silt Loam. A few small areas occur in the midst of the sandy soils of the broad terrace in the eastern part of the county. The topography varies from flat to slightly undulating. The areas north of the river appear to have been formed under conditions of better drainage than those south of the river.

The surface, which is about 9 inches deep, is a black clay loam over most of the area. The subsurface varies considerably in depth, in some areas extending to the till with no subsoil development while in others it is very thin. However, it is uniformly a pale yellow or yellowish brown, mottled, silty clay loam. The subsoil is found at depths varying from 10 to 20 inches, depending upon the development of the subsurface stratum. It consists of a dark yellow, slightly mottled clay, or of till.

South of the river the surface to a depth of 8 to 12 inches is a black to drab clay loam. The subsurface, which extends to a depth of 14 to 22 inches, is a drab clay loam. The subsoil is variable in texture and color, but over a large portion of the area, is a bluish drab clay.

Management.—This type does not need limestone for the most part, altho north of the river there are small areas which test acid. The subsoil thruout the type contains carbonates. South of the river some areas are distinctly alkaline, tho probably never sufficiently so to be harmful. The important requirement in the management of this type is to improve the drainage on areas which are not now well drained and to make provision for returning fresh organic matter as a means of maintaining a condition of good tilth.

Brown Sandy Loam (1560)

Brown Sandy Loam occurs principally in a large body in the eastern part of the county and represents a wide terrace extending into this county from Kankakee and Will counties. This terrace was formed by the Glacial Kankakee river. The type covers 49.45 square miles, or more than one-tenth of the area of the county. The topography is mostly flat with occasional undulations produced by dunes that have been covered by fine material. These slight elevations constitute a slightly better phase than the flat, somewhat poorly drained areas.

The surface, which is about 8 inches deep, varies from a brown sandy silt loam to a sand. The subsurface is a yellowish brown to gray sandy loam varying in thickness from 6 to 20 inches with an average of about 14 inches. In the low, poorly drained areas, the soil frequently changes at a depth of 8 to 12 inches to a gray sandy loam a little coarser in texture than that on the low ridges. The subsoil, which begins at 14 to 28 inches, is usually yellow, grayish yellow, or gray in color and varies from a sand to a silty sand, with the sand predominating.

Management.—As a general rule, the drainage of the undulating phase of the type is fair, but in the flat phase, artificial drainage is necessary in many cases. Because of the perviousness of the strata, drainage takes place readily if a good outlet can be obtained. Some difficulty, however, is encountered in the case of open ditches, which tend to fill up rapidly with sediment, and if tile is used, fine sand sometimes runs into the tile to a troublesome extent.

In the management of this type, it is very necessary that the organic-matter content be maintained. Crop residues, manure, and legumes should be turned under. The application of limestone is not usually necessary except on the higher areas. The type is low in phosphorus. On this very sandy soil so deficient in organic matter, it probably would be advantageous to use one of the more readily soluble forms of phosphate, such as bone meal or acid phosphate.

Yellow-Gray Silt Loam (1534)

Yellow-Gray Silt Loam, Terrace, comprizes about 2½ square miles, or .6 percent of the area of the county. The largest area of this type is in the northeast part of the county along Aux Sable creek. It is distributed in rather small isolated areas along the Illinois terrace and to some extent along Mazon river. The topography is slightly undulating, owing to the presence of old stream channels. There is no distinct layer of sand or gravel in the subsoil. Many boulders occur in this type.

The surface, which is 6 to 8 inches in depth, is a yellowish gray to grayish brown silt loam containing an appreciable amount of fine and medium sand. The organic-matter content is low. The subsurface varies greatly in thickness; in some areas it does not exceed 3 inches, while in others it is 10 or 12 inches thick. It is a grayish yellow silt loam, usually containing an appreciable amount of sand. The subsoil is a yellow or yellowish drab clayey silt loam or clay loam, with some gravel at 24 to 28 inches. Where gravel is encountered, strong effervescence with acid shows the presence of carbonate.

Management.—The type is low in nitrogen and in phosphorus in the surface soil; however, the phosphorus content to a depth of 40 inches compares very favorably with most of the other types in the county. Tests indicate lack of carbonate in the upper soil, but an abundance in the subsoil. An application of limestone of about 2 tons per acre, in order to insure the thrifty growth of legumes, is suggested as the first step towards more profitable production. Clovers, especially deep-rooting sweet clover, is an excellent crop for this type, and every means should be used to get the soil in condition for growing sweet clover. Experiment field results on a very similar type indicate that the available forms of phosphate can be used at a profit on this type of soil.

Yellow-Gray Sandy Loam (1564)

Yellow-Gray Sandy Loam occupies a large share of the terrace of the Mazon river. It covers an area of 1,338 acres, or .49 percent of the area of the county. In topography it resembles the Yellow-Gray Silt Loam just described.

The surface, which is 6 to 7 inches deep, is for the most part a grayish brown sandy loam, altho it varies from a sandy silt loam to a sand. The organic-matter content is low. The subsurface, extending to a depth of about 19 inches, is a yellowish gray sandy loam. The subsoil to a depth of 24 to 38 inches, is a yellowish gray sandy clay which then passes into a gray coarse sand.

Management.—This type requires approximately the same management as the preceding one, Yellow-Gray Silt Loam. It is, however, a poorer soil, and probably will not respond so satisfactorily to good treatment and management.

Brown-Gray Silt Loam On Tight Clay (1528)

The total area of Brown-Gray Silt Loam On Tight Clay, Terrace, in the county amounts to 205 acres. The largest area is in Sections 29 and 30, Township 33 North, Range 8 East (Gooselake). The topography of this type is flat and the presence of the tight clay subsoil hinders underdrainage very seriously.

The surface to a depth of about 8 inches is a grayish brown to brown silt loam, fairly well supplied with organic matter. The subsurface is a stratum of gray silt loam 3 to 6 inches in thickness. The subsoil found at a depth of 11 to 14 inches, is a gray to drabbish brown, plastic, impervious clay.

Management.—Two or three tons of limestone per acre should be applied. Sweet clover is recommended as a good legume to grow, for it furnishes a liberal supply of needed organic matter and nitrogen. Good surface drainage by means of open furrows should be provided for. While effective underdrainage is one of the greatest needs of this soil, as mentioned above, no practicable means is known of securing it.

Brown-Gray Sandy Loam On Tight Clay (1568)

Brown-Gray Sandy Loam On Tight Clay, Terrace, occurs almost entirely south of the Illinois river. It occupies only 134 acres. The topography is flat and the land is poorly drained.

The surface, which is 7 to 12 inches deep, is a brown sandy loam which, when dry after a rain, has a grayish appearance. It is low in organic matter. The subsurface, which extends to a depth of 20 to 40 inches, is a gray sandy loam. The subsoil is a dark yellowish drab to gray clayey sand, plastic and impervious.

Management.—In the management of this type, one of the first requirements after the drainage has been taken care of, as suggested for Brown-Gray Silt Loam On Tight Clay, Terrace, is the application of about 2 tons of limestone per acre in order to insure the successful growth of legumes. Sweet clover is recommended as a good legume for maintaining organic matter and nitrogen, and there is a possibility that its deep-rooting habit tends to open up the subsoil and promote better drainage. The chemical analysis indicates that this type is relatively low in the elements of plant food. No experimental results are available as to the treatment of this type; however, the known response of crops suggest the trying in an experimental way of a soluble phosphate for wheat, and a potash salt, either potassium chloride or sulfate, for corn.

Dune Sand (1581)

Dune Sand occurs principally in the sandy terrace south of the Illinois river. The topography is slightly undulating, there being no very high dunes in this county as a general rule. There is a total of 6.62 square miles mapped as this type, or 1.55 percent of the area of the county.

The surface soil, to a depth of 8 or 10 inches, is a medium sand, mixed with some fine sand and a small amount of silt. It varies in color from yellow to light brown. It is very low in organic matter. There is no true subsurface and subsoil development. Below the surface a yellow color predominates to a depth of 20 to 30 inches, where it becomes drabbish yellow. There is but little change in texture with depth.

Management.—The sand in this county is better as a rule than most dune sand, owing to its finer texture. It contains more or less fine sand, as well as a slight amount of silt. It will, therefore, retain plant food, organic matter, and moisture better than the ordinary dune sand, and it is not so likely to drift.

This soil is extremely deficient in organic matter, nitrogen, and sulfur and is low in phosphorus. A program of improvement involves the liberal use of legumes, which, in connection with the use of phosphates in a readily available form, and potassium salts, would probably prove profitable. Carbonates appear to be lacking, so the first recommendation would be to apply 2 to 4 tons of limestone per acre, and then to grow legumes at every opportunity. Where these patches of dune sand are already wooded, it is advisable to retain them as permanent pasture rather than to attempt to cultivate them. (See account of Oquawka field, page 64 of the Supplement.)

Black Sandy Loam (1561)

Black Sandy Loam occurs in the sandy terrace area south of the Illinois river. The topography is flat and as a general rule the type is very poorly drained.

The surface, which is about 9 inches deep, is a black sandy loam varying toward a peaty loam in small areas. It is well supplied with the more inert forms of organic matter, but is generally deficient in the active forms. The subsurface to a depth of about 19 inches is a brownish black sandy loam. The subsoil is a yellow, grayish yellow, or brown sand which passes into a coarse gray sand at about 40 inches.

Management.—The first requirement of this type is drainage. Since all strata are pervious, underdrainage may be provided very readily if there is an adequate outlet. Alkali spots occur which may be corrected either by growing sweet clover frequently and turning it under or by applying potassium salts at regular intervals. It is an excellent plan to grow a legume in the rotation and turn it under as a source of readily decomposable organic matter and available nitrogen.

Brown Sandy Loam On Rock (1560.5)

Brown Sandy Loam On Rock is associated with Brown Silt Loam On Rock.

The surface soil is a brown sandy loam which varies in depth from 1 or 2 inches, where the rock comes near the surface, to 8 or 10 inches, where the rock lies at a depth of about 20 inches or more. This stratum is well supplied with organic matter. The subsurface soil is a yellow to brownish yellow sandy loam.

The depth of the sandstone or limestone bed rock determines the thickness of this stratum. It varies from 0 to 20 inches or more.

Management.—This is a very shallow soil and is consequently subject to drouth. It is somewhat better stocked with plant food than the average sandy loam, and is good pasture land, but it is unsuited to cropping over much of the area.

Brown Silt Loam On Rock (1526.5)

With the exception of a few small, isolated areas, Brown Silt Loam On Rock occurs in the northeast part of the county south of that part of the Illinois river where it bends abruptly southwest. The topography is undulating and there are occasional outcrops of limestone. A considerable portion of the area contains large glacial boulders in such abundance that it is not practicable to bring it under cultivation.

The surface, to a depth of about 8 inches, is a brown silt loam containing an appreciable amount of fine sand. The organic-matter content is high. The subsurface generally extends to limestone rock, which is usually found at depths varying from 11 to 20 inches, altho in some small spots the bare rock is exposed on the surface.

Management.—This soil is unusually rich in the plant-food elements and under favorable weather conditions is very productive. It is so shallow, however, that it does not resist drouth very well, and for this reason much of it is in pasture. If cropped at all, early maturing crops should be grown so that the greatest demand for moisture will come early in the season.

Brown Sandy Loam Over Gravel (1566)

Brown Sandy Loam Over Gravel occupies about one square mile. It is found just south of the junction of the Illinois and Mazon rivers. The topography is slightly undulating and the depressions probably represent old channels of rapid currents.

The surface to a depth of 8 or 9 inches is a brown sandy loam containing a considerable proportion of coarse sand. It is low in organic matter. The subsurface is found at about 9 inches in depth and varies from 4 to 10 inches in thickness. It is a light brown to yellowish brown sandy loam. The sand is coarse, similar to that of the surface. The subsoil is a yellow sandy loam containing coarse sand and some gravel. Rather pure gravel occurs at depths varying from 30 to 40 inches.

Management.—This type is low in nitrogen; consequently legumes should be grown at frequent intervals to increase the amount of organic matter and nitrogen. The surface soil of this type shows slight acidity, and for the best growth of alfalfa or sweet clover, about 2 tons of limestone per acre is recommended. The subsoil at a depth of 30 to 40 inches may contain large quantities of carbonates and when this is the case, it is likely that the initial limestone application will be sufficient for an unusually long period.

Yellow-Gray Sandy Loam On Gravel (1564.4)

The only area of Yellow-Gray Sandy Loam On Gravel in Grundy county occurs just across the river south of Stockdale. It is a small tract of only 64 acres. The topography is undulating.

The surface, which is about 7 inches deep, is a brownish gray sandy loam containing very coarse sand and some fine gravel. The subsurface varies in thickness from a very thin stratum to a maximum of about 8 inches, according to the depth of the gravel. It is ordinarily found at a depth of about 7 inches and is a yellow, very coarse, sandy loam containing some fine gravel. Practically pure gravel occurs at depths varying from 7 to 30 inches.

Management.—The type should receive practically the same management as Brown Sandy Loam On Gravel (1560.4), a discussion of which follows.

Brown Sandy Loam On Gravel (1560.4)

Brown Sandy Loam On Gravel occurs on both sides of the Illinois river, the largest areas being south of the river nearly opposite the town of Morris. The type covers an area of 1,792 acres, or .65 percent of the area of the county. The topography is undulating.

The surface, which is a brown sandy loam, varies greatly in depth. It sometimes extends to a depth of 14 or 15 inches where gravel is encountered. Ordinarily, however, it is 7 to 9 inches in depth and grades into a yellowish brown sandy loam subsurface. Below the subsurface, beginning at a depth of 14 to 20 inches, gravel with a high carbonate content is encountered. The gravel is nearer the surface on the higher parts; in the lower places the soil is darker and the gravel may lie as much as 36 inches beneath the surface, altho these areas are usually not large enough to be indicated on the map.

Management.—The fact that the stratum of soil above the gravel is rather thin accounts for the drouthy nature of this type. The growing of legumes is advised. The use of early maturing crops is also desirable, in order that the period of the greatest need of moisture by the crop will be past before the driest part of the season approaches.

(d) LATE SWAMP AND BOTTOM-LAND SOILS

In the group designated as late swamp and bottom-land soils are included the bottom lands or flood plains along streams, the swamps, the poorly drained lowlands, and also all peats and mucks, whether on upland or terrace. Much of the soil is of alluvial formation, and the land is largely subject to overflow. A large part of the county was entered in the government records as swamp land, but these former swamps are, for the most part, now sufficiently well drained to produce excellent crops. There is some of this land, however, that needs more drainage. The total area in the county classed here as swamp and bottom land amounts to 27.37 square miles, or 6.4 percent of the area of the county.

Deep Brown Silt Loam (1426)

Deep Brown Silt Loam occurs extensively along the Illinois river as well as along some of the smaller streams. The topography is flat to slightly undulating, the undulations being caused by overflow channels or by abandoned stream courses.

The surface is 10 to 14 inches in depth. It varies from a clayey silt loam to a sandy loam, and generally contains a considerable percentage of sand. It is well supplied with organic matter. The subsurface is slightly lighter in color than the surface and passes into a yellowish drab colored subsoil at 18 to 30 inches.

Management.—Practically all of the type is subject to overflow. The sediment deposited during each overflow period maintains a good supply of plant-food elements. Good cultivation, then, is the principal factor for consideration in the management of this type.

Mixed Loam (1454)

Mixed Loam occurs as bottom land along the small streams, principally in the central part of the county. It usually takes the form of narrow strips which are rarely more than a quarter of a mile wide.

This type is in reality 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. Since this type as mapped is a mixture of a number of types, it is impossible to write a description of it which will apply to the type as a whole. For the same reason, no attempt is made to show chemical composition in the tables of plant-food elements. The same management is required as that advised for Deep Brown Silt Loam.

Black Clay Loam (1420)

Black Clay Loam, Bottom, occurs in the Illinois river bottom, near the junction of Aux Sable creek and the Illinois river. It is flat in topography and is subject to overflow.

The surface, which is about 8 inches deep, is a black, plastic, granular, heavy clay loam. The subsurface is 4 to 10 inches in thickness. It is usually drabbish in color and is slightly heavier than the surface soil. The subsoil, which begins at 12 to 20 inches, is a drab or grayish drab, heavy, plastic clay.

Management.—Drainage is the first requirement of this type, but draining is usually very difficult, not because of the impervious character of the soil, but on account of the difficulty of obtaining a good outlet. Because of its heavy character it is necessary that this soil be kept well supplied with organic matter in order to help in the maintenance of a good physical condition. Limestone is not needed.

Brown Sandy Loam (1460)

Brown Sandy Loam occurs in the bottom lands of the Illinois river, fairly well distributed thruout this area. The topography is flat to slightly undulating.

The surface, 8 to 12 inches in depth, is, for the most part, a brown sandy loam, but varies toward a silt loam on the one hand and toward a sand on the other. It is fairly well supplied with organic matter. This type, in common with other bottom-land types, shows no development of distinct subsurface and subsoil strata. At a depth of 8 to 12 inches the color becomes lighter, and gravel is frequently found at a depth of 16 to 20 inches.

Management.—Practically all of this type is subject to overflow and thus the soil receives a deposit which helps to maintain the supply of plant-food elements. The drainage of the lower and flatter areas is a difficult problem, altho as a general rule this type is the higher part of the overflow bottoms along the Illinois river. Another difficulty with this type is that some areas where the sand is coarse are subject to drouth. Good cultivation is the important part of the management of this type. The surface soil of some portions of the area is slightly acid; however, since carbonate is usually found within 20 inches of the surface and the land is subject to overflow, it is probably not necessary to apply limestone. In case overflow prevents the growing of biennial and perennial legumes, such as the clovers and alfalfa, then the frequent use of annuals, such as cowpeas and soybeans, is advised. Legumes of any kind plowed under directly as green manure ought to prove especially beneficial to the crops that follow.

Black Mixed Loam (1450)

Black Mixed Loam occurs in the bottom land of the Illinois river both on the north and the south sides of the stream. Boulders are scattered pretty generally over the surface of this type.

The surface soil varies in texture from clay loam to sandy loam and may contain spots that are peaty in character. The organic-matter content is also extremely variable. These differences, together with similar subsurface and subsoil differences, occur in such small areas that type separations cannot be made.

Management.—The first requirement of this type is drainage. Draining is frequently difficult because of the lack of an outlet and also because of the fact that the land is often flooded. The soil is, however, very productive. There are small areas of alkali. The growing of sweet clover will do much to counteract the harmful effect of the alkali. Much of the Black Mixed Loam is not cultivated but is left in pasture, principally because of the fact that it cannot be drained satisfactorily.

Peaty Loam On Clay (1410)

The area mapped as Peaty Loam On Clay occurs in the bottom lands of the Illinois river in the northwest part of Township 33 North, Range 8 East (Gooselake). It is subject to overflow from the river.

This area varies from Peaty Loam On Sand or Peaty Loam On Clay around the edges to Deep Peat thru the center. It is high in inert, well decomposed, organic matter. Alkali is present over much of the area in sufficient amount to be harmful.

Management.—Drainage is the first requirement. The application of potassium would probably be beneficial in helping to overcome the effect of the alkali on the growing crop even tho it, as well as all of the other elements of plant food, is naturally present in abundance.

Medium Peat On Clay (1402)

A small area of Medium Peat On Clay occurs in the vicinity of Peaty Loam On Clay. The land is very low and swampy and is subject to overflow in time of medium high water.

The surface, 12 to 16 inches in depth, is a black, well-decomposed peat. A stratum of dark yellow, strongly mottled, silty clay loam is then found to a depth of about 30 inches, at which point peat again occurs and extends to a depth of 7 feet or more.

Management.—Drainage is the first requirement of the type. Potassium is deficient in the surface sample (0 to 6⅔ inches); however, it is abundant in the 40-inch section. Phosphorus is deficient in the first 20 inches. The presence of alkali in this area suggests that potassium might be beneficial. Experimental results in other states indicate that on a soil of this character phosphates are beneficial.

Deep Peat (1401)

A few areas of Deep Peat occur in the bottom land of the Illinois river. Another one occurs in Township 33 North, Range 8 East, and occupies a part of an area that was formerly known as Goose Lake, but which has recently been drained and is now under cultivation.

The soil is a black, well decomposed peat to a depth of 30 to 40 inches. Below this depth a varying amount of coarse sand is mixed with the peat.

Management.—Drainage is the first requirement. In the installation of the drains a difficulty is met in the case of tile drainage, because the loose character of the peat makes it difficult to hold the tile in line. This trouble may be overcome by putting boards in the bottom of the ditch and laying the tile on the boards. Peat is usually deficient in the element potassium and it has been found to be profitable to supply that element in amounts of 100 to 200 pounds or more of potassium salts per acre for the corn crop. The type is always well provided with nitrogen. A considerable portion of the Goose Lake area has been burned over and its nature thus changed. Large boulders are found over portions of this area. No experimental data are available regarding the treatment of these burned over areas, but it is not likely that potassium salts are required on them. (See account of Manito experiment field, page 66 of the Supplement.)

Muck On Clay (1413)

Muck On Clay is found in a long, narrow depression south of the river just across from Morris, and in a small area in Section 23, Township 31 North, Range 6 East (Highland).

The surface, 8 to 12 inches in depth, is a black, granular muck. This passes into black clay which extends below the 40-inch depth examined.

Management.—Drainage is the first requirement, and this, followed by good cultivation, is practically all that will be necessary for a long period of time before any fertilization will be needed.

Muck On Marl (1413.6)

Muck On Marl occurs only in one area, 6 acres in extent, in Section 30, of Good Farm township (Township 31 North, Range 7 East).

The soil to a depth of about 10 inches is a very heavy black muck, granular and somewhat plastic when very wet. It passes into a black clay loam which rests on marl at a depth of about 20 inches. The marl extends to a depth of about 60 inches, at which point highly calcareous, coarse, gray sand is encountered.

Management.—The type needs drainage and good cultivation. Analysis shows the marl to contain about 53 percent calcium carbonate equivalent.

(e) RESIDUAL SOILS

Residual soils are formed from the residue left in place by the weathering of rock and the accumulation of organic matter. Such soils are found in the valley of the Illinois river where the former stream has swept all the glacial material from the rock leaving it exposed. This rock was a shaly sandstone which weathers readily, and to a depth of 10 to 28 inches it has decomposed into soil material.

Brown Sandy Loam On Rock (060.5)

Brown Sandy Loam On Rock occurs principally in the western part of the county. It covers an area of 857 acres, or .31 percent of the area of the county. The topography is flat to slightly undulating.

The surface, which is about 8 inches deep, is a brown to dark brown sandy loam and contains a few fragments of the shaly sandstone rock from which it was derived. Glacial boulders are found in abundance in the surface soil over portions of the area. It is well supplied with organic matter. The subsurface varies from 10 to 18 inches in thickness and is a yellowish brown or yellowish gray silty sand containing fragments of the shaly sandstone. The sandstone rock which is found at a depth of 18 to 26 inches is so thoroly weathered that it may be penetrated by the auger without a great deal of difficulty.

Management.—Residual Brown Sandy Loam On Rock is not a very good type of soil. It is generally strongly acid and the first requirement in building up this type is an application of 2 or 3 tons of limestone per acre. Crop residues, farmyard manure, and legumes should be turned under. In favorable seasons this soil would probably respond to phosphorus and potassium treatment; however, because of the shallowness of the soil, successful cropping is likely to be uncertain. If the land is cultivated, it is advisable to raise early maturing crops. It probably would be safer to continue using this type mainly as pasture land, as much of it is now used.

Yellow-Gray Sandy Loam On Rock (064.5)

Yellow-Gray Sandy Loam On Rock occurs in the same locality as the preceding type but in much smaller area. There are only 128 acres. This land is slightly undulating.

The surface, which is 6 to 8 inches deep, is a light brown to yellowish gray sandy loam containing fragments of the original rock. It is deficient in organic matter. The subsurface soil varies in depth according to the distance to rock and this varies roughly from 7 to 30 inches. The soil material is a yellow to gray sandy loam and in the extreme may even vary to a sand. The shaly sandstone is rather rotten and it is not difficult to dig ditches for drainage purposes. In this, as well as in the preceding type, large numbers of glacial boulders are present.

Management.—This type, while it is much lower in nitrogen and organic matter than Brown Sandy Loam On Rock, is a better soil, judging from its native vegetation. It does not test acid as does the corresponding prairie type (1164.5). Excepting for the limestone recommendation, the same management is advised as for Brown Sandy Loam On Rock (060.5).

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 used.

The type is the unit of classification and each type has definite characteristics. In establishing types, the following factors are taken into account: the character of the horizons composing the soil as to depth and thickness, physical composition, structure, organic-matter content, color, reaction, and carbonate content; the topography; the native vegetation; and the geological origin of the soil.[1]

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made whenever the areas involved are sufficiently large. Because of the almost infinite variability occurring in soils, one of the exacting tasks of the soil surveyor is to determine the degree of variation which is allowable for any given type.

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[1] Since some of the terms used in designating the factors which are taken into account in establishing soil types are technical in nature, the following explanations are introduced:

Horizon. A layer or stratum of soil which differs discernibly from those adjacent in color, texture, structure, chemical composition, or a combination of these characteristics, is called an horizon.

Depth and Thickness. The horizons or layers which make up the soil profile vary in depth and thickness. These variations are distinguishing features in the separation of soils into types.

Physical Composition. The physical composition, sometimes referred to as "texture," is a most important feature in characterizing a soil. The texture depends upon the relative proportions of the following physical constituents: clay, silt, fine sand, sand, gravel, stones, and organic material.

Structure. The term "structure" has reference to the aggregation of particles within the soil mass and carries such qualifying terms as open, granular, compact.

Organic-Matter Content. The organic matter of soil is derived mainly from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter constitutes the predominating constituent in certain soils of swampy formation.

Color. Color is determined to a large extent by the proportion of organic matter, but at the same time it is modified by the mineral constituents, especially by iron compounds.

Reaction. The term "reaction" refers to the chemical state of the soil with respect to acid or alkaline condition. It also involves the idea of degree, as strongly acid or strongly alkaline.

Carbonate Content. The carbonate content has reference to the calcium carbonate (limestone) present, which in some cases may be associated with magnesium or other carbonates. The depth at which carbonates are found may become a very important factor in determining the soil type.

Topography. Topography has reference to the lay of the land, as level, rolling, hilly, etc.

Native Vegetation. The vegetation or plant growth before being disturbed by man, as prairie grasses and forest trees, is a feature frequently recognized in determining soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil.

Classifying Soil Types.—In the system of classification used, the types fall first into four general groups based upon their geological relationships; namely, upland, terrace, swamp and bottom land, and residual. These groups may be subdivided into prairie soils and timber soils, altho as a matter of fact this subdivision is applied in the main only to the upland group. These terms are all explained in the foregoing part of the report in connection with the description of the particular soil types.

Naming and Numbering Soil Types.—In the Illinois soil survey a system of nomenclature is used which is intended to make the type name convey some idea of the nature of the soil. Thus the name "Yellow-Gray Silt Loam" carries in itself a more or less definite description of the type. It should not be assumed, however, that this system of nomenclature makes it possible to devise types names which are adequately descriptive, because the profile of mature soils is usually made up of four or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "on," and when its depth exceeds 30 inches, by the word "over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their corresponding index numbers are given in the following list.

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

For further information regarding these geological areas the reader is referred to the general map published in Bulletins 123 and 193.

Another set of index numbers is assigned to the classes of soils as based upon physical composition. The following list contains the names of these classes with their corresponding index numbers.

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

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the balance of the number designates the type. To illustrate: the number 1126 means Brown Silt Loam in the early Wisconsin glaciation, 434 means Yellow-Gray Silt Loam of the middle Illinoisan glaciation. These numbers are especially useful in designating very 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 in connection with the maps.

SOIL SURVEY METHODS

Mapping of Soil Types.—In conducting the soil survey, the county constitutes the unit of working area. The field work is done by parties of two to four men each. The field season extends from early in April to Thanksgiving. During the winter months the men are engaged in preparing a copy of the soil map to be sent to the lithographer, a copy for the use of the farm adviser until the printed map is available, and a third copy for use in the office in order to preserve the original official map in good condition.

An accurate base map for field use is necessary for soil mapping. These 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 the 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, town sites, and rock and gravel quarries are placed in their proper location upon the map while the mapper is on the area. With the rapid development of road improvement during the past few years, it is almost inevitable that some recently established roads will not appear on the published soil map. Similarly, changes in other artificial features will occasionally occur in the interim between the preparation of the map and its publication. The detail or minimum size of areas which are shown on the map varies somewhat, but in general a soil type if less than five acres in extent is not shown.

A soil auger is carried by each man with which he can examine the soil to a depth of 40 inches. An extension for making the auger 80 inches long is taken by each party, so that the deeper subsoil may be studied. Each man carries a compass to aid in keeping directions. Distances along roads are measured by a speedometer or other measuring device, while distances in the field away from the roads are measured by pacing.

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. The samples for this purpose are usually taken in three depths; namely, 0 to 6⅔ inches, 6⅔ to 20 inches, and 20 to 40 inches, as explained in connection with the discussion of the analytical data on page 8.

PRINCIPLES OF SOIL FERTILITY

Probably no agricultural fact is more generally known by farmers and landowners than that soils differ in productive power. A fact of equal importance, not so generally recognized, is that they also differ in other characteristics such as response to fertilizer treatment and to management.

The soil is a dynamic, ever-changing, exceedingly complex substance made up of organic and inorganic materials and teeming with life in the form of microorganisms. Because of these characteristics, the soil cannot be considered as a reservoir into which a given quantity of an element or elements of plant food can be poured with the assurance that it will respond with a given increase in crop yield. In a similar manner it cannot be expected to respond with perfect uniformity to a given set of management standards. To be productive a soil must be in such condition physically with respect to structure and moisture as to encourage root development; and in such condition chemically that injurious substances are not present in harmful amounts, that a sufficient supply of the elements of plant food become available or usable during the growing season, and that lime materials are present in sufficient abundance favorable for the growth of the higher plants and of the beneficial microorganisms. Good soil management under humid conditions involves the adoption of those tillage, cropping, and fertilizer treatment methods which will result in profitable and permanent crop production on the soil type concerned.

The following paragraphs are intended to state in a brief way some of the principles of soil management and treatment which are fundamental to profitable and continued productivity.

CROP REQUIREMENTS WITH RESPECT TO PLANT-FOOD MATERIALS

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.* 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 in one or more of the elements of plant food.

TABLE A.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

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
Soybean seed	1 bu.	3.22	.39	.27	1.26	.15	.14	.....
Soybean hay	1 ton	43.40	4.74	5.18	35.48	13.84	27.56	.....
Alfalfa hay	1 ton	52.08	4.76	5.96	16.64	8.00	22.26	.....

[1]These data are brought together from various sources. Some allowance must be made for the exactness of the figures because samples representing the same kind of crop or the same kind of material frequently exhibit considerable variation.

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

SUPPLY OF PLANT-FOOD ELEMENTS

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

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

TABLE B.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

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)[2]	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[3] (unleached)	...	10	100

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

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 some of the more important plant-food elements contained in materials most commonly used as sources of supply.

LIBERATION OF PLANT-FOOD ELEMENTS

The chemical analysis of the soil gives the invoice of plant-food elements 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 elements as calcium and phosphorus, converting them into available forms 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 elements are liberated for the benefit of the cereal crops which follow in the rotation. Moreover, as an effect of the deep-rooting habit of these legumes, 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 supplies calcium, thus encouraging 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 unavailable organic nitrogen into 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 compounds.

Organic Matter and Biological Action.—Organic matter may be supplied thru animal manures, consisting of the excreta of animals and usually accompanied by more or less stable litter; and by plant manures, including green-manure crops and cover crops plowed under, and also crop residues such as stalks, straw, and chaff. The rate of decay of organic matter depends largely upon its age, condition, and origin, and it may be hastened by tillage. The chemical analysis shows correctly the total organic carbon, which constitutes, as a rule, but little more than half the organic matter; so that 20,000 pounds of organic carbon in the plowed soil of an acre corresponds to nearly 20 tons of organic matter. But this organic matter consists largely of the old organic residues that have accumulated during the past centuries because they were resistant to decay, and 2 tons of clover or cowpeas plowed under may have greater power to liberate plant-food materials 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 available 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 elements 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 materials are 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 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 inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement.

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

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

How to Ascertain the Need for Limestone.—One of the most reliable indications as to whether a soil needs limestone is the character of the growth of certain legumes, particularly sweet clover and alfalfa. These crops do not thrive in acid soils. Their successful growth, therefore, indicates the lack of sufficient acidity in the soil to be harmful. In case of their failure to grow the soil should be tested for acidity as described below. A very valuable test for ascertaining the need of a soil for limestone is found in the potassium thiocyanate test for soil acidity. It is of value to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonate of calcium and magnesium. The natural occurrence of these carbonates in the soil is sufficient assurance that no limestone is needed, and the acidity test will be negative. On lands which have been treated with limestone, however, the surface soil may give a positive test for carbonates, due to the presence of undecomposed pieces of limestone, and at the same time a positive test for acidity may be secured. Such a result means either that insufficient limestone has been added, or that it has not been in the soil long enough to entirely correct the acidity. In making these tests, it is desirable to examine samples of soil from different depths, since carbonates may be present, even in abundance, below a surface stratum that is acid. Following are the directions for making the tests:

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol (not denatured). When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. In testing, therefore, the sample should be about as dry as when the soil is 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 hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence, and indicates that the soil contains limestone or some other carbonate. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

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 usually 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 plant growth. 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 fixing atmospheric nitrogen, 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 will ever be able to replace the simple method of obtaining atmospheric nitrogen by growing inoculated legumes in the production of our great grain and forage crops.

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 cowpea hay 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 the soil is dependent upon the origin of the soil. The removal of phosphorus by continuous cropping slowly reduces the amount of this element in the soil available for crop use, unless its addition is provided for by natural means, such as overflow, or by agricultural practices, such as the addition of phosphatic fertilizers and rotations in which deep-rooting, leguminous crops are frequently grown.

It should be borne in mind in connection with the application of phosphate, or of any other fertilizing material, to the soil, that no benefit can result until the need for it has become a limiting factor in plant growth. 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 only 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 likewise an element of plant food. 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, or 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 under any given set of conditions.

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 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 the phosphorus from 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, which are silt loams and clay loams, are well stocked with potassium, altho it exists largely in a slowly soluble 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, with a few exceptions, 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 elements 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 $6\frac{2}{3}$ 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 consider also the loss by leaching.

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 lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, 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.

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 matter, 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, slightly 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 undergoing destruction during a large part of the year and the nitrates produced in its decomposition are used for plant growth. Altho this decomposition is neccessary, 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. There is considerable evidence indicating that on some soils undecomposed straw applied in excessive amount may be detrimental. Probably the best practice is to apply the straw as a constituent of well-rotted stable manure. Perhaps 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, for the reasons discussed above, a liberal use of legumes. 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 —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 —Corn
Second year —Cowpeas or soybeans
Third year —Wheat (with clover)
Fourth year —Clover

First year —Wheat (with clover)
Second year —Clover
Third year —Corn
Fourth year —Oats (with 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. Or, in some cases, it may become desirable to divide the acreage of small grain and grow in the same year more than one kind. 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 on Soil Types Similar to those Occurring in Grundy 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 located on 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

The soil experiment 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 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. 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 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. Besides farm manure, 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.

Table 1 gives the yearly records of the crop yields from the Morrow plots, and Table 2 presents the results 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]
1922	None	24.6	....	39.3	49.2	....	....
1922	MLP	39.4	....	55.8	65.3	....	....
1923	None	15.0	17.2	....	....	53.4	....
1923	MLP	31.4	~~14.4~~ 46.4	....	....	66.6	....

[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)
		20 crops	*10 crops*	*10 crops*	*7 crops*	*7 crops*	*4 crops*
1904 to 1923	None........	25.5	36.5	34.9	51.1	45.2	(1.23)[1]
	MLP........	40.6	58.0	55.3	67.7	59.5	(2.21)[1]

[1]One crop of soybean hay included. 61.2

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 untreated 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 provision is made for each crop in the rotation to be represented every year. These plots were laid out in 1895, but special soil treatment was not begun until 1901. They now comprize five series of ten plots each, and each series constitutes a "field" in a crop rotation system.

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

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

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

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

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

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

Potassium (**K**) 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 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 the corresponding 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, manure has been decidedly more effective than residues, 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 during the twelve years there were five clover failures, when soybeans were substituted. 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 practically all crops. What the financial profit

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

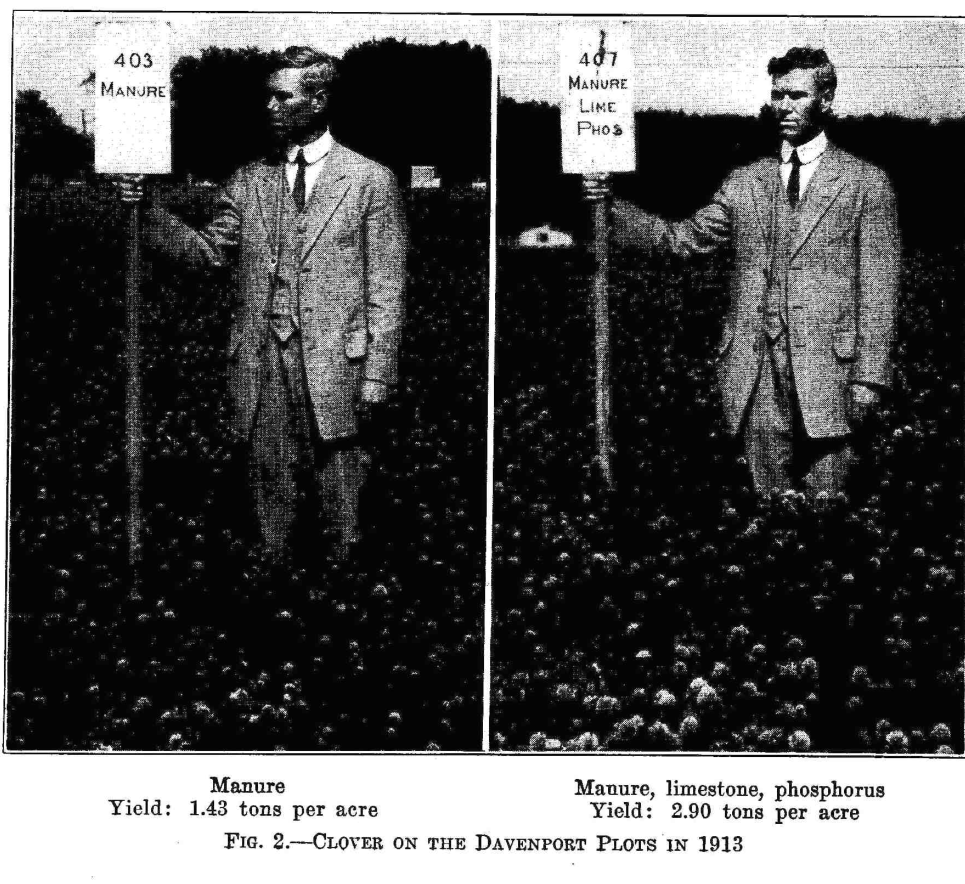
Average Annual Yields—Bushels or (tons) per acre
1911-1922

Serial plot No.	Soil treatment applied	Corn *12 crops*	Oats *12 crops*	Wheat *12 crops*	Legumes: Clover *7 crops*	Legumes: Soybeans *5 crops*	Alfalfa *12 crops*
1	0	55.6	52.5	25.9	(2.04)	(1.47)	(2.40)
2	R	56.3	53.7	28.4	1.42[1]	19.8	(2.54)
3	M	65.8	64.5	29.0	(2.21)	(1.62)	(2.51)
4	RL	64.4	56.0	31.5	1.64[1]	20.3	(2.79)
5	ML	69.9	64.4	33.8	(2.68)	(1.67)	(3.04)
6	RLP	71.3	69.0	42.1	1.90[1]	23.5	(3.85)
7	MLP	72.6	68.8	40.3	(3.26)	(1.97)	(3.92)
8	RLPK	70.8	71.4	39.9	1.51[1]	25.5	(4.02)
9	MLPK	70.0	71.4	39.3	(3.25)	(2.20)	(3.92)
10	Mx5LPx5	65.6	71.0	40.1	(2.84)	(2.22)	(3.92)

[1]In addition to the clover seed a crop of hay was taken from Plots 2, 4, 6, and 8 in the year 1918 and again in 1921, producing as an annual average for the seven years .46, .51, .59 and .59 tons respectively.

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



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

effect on wheat is especially pronounced. Where limestone and phosphorus are applied in addition to the crop residues, an increase of 16 bushels of wheat, over the yield of the untreated land, has been obtained as a twelve-year average.

The effect of adding potassium to the treatment is of much interest. Plots 8 and 9 are similar to Plots 6 and 7, respectively, except that potassium has been applied to the former. The small gains appearing in certain cases are counterbalanced by losses in others so that on the whole potassium treatment has not been profitable on these plots.

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 re-

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.

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

On the whole, the "residues" have not returned as high yields 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 relatively 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 on this field solely in the form of raw rock phosphate. The figures in almost every case show an increase in yield where the phosphate has been applied, and in most cases this increase is very pronounced. The wheat is especially responsive to phosphorus.

The records from this field 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 Grundy county are introduced here. One of these fields is located near Joliet in Will county and the other at Minonk in Woodford county.

In considering the results from these two fields it should be pointed out that they represent opposite phases of Brown Silt Loam. The Joliet field is 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 between the two fields in response to soil treatment. Probably most of the Brown Silt Loam as it exists in Grundy county lies somewhere between these two extremes with a relatively small proportion characteristic of the Joliet field. 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.

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

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.

Residues, alone, have 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 response to 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 to 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 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.

YELLOW-GRAY SILT LOAM

Only one soil experiment field has been conducted on Yellow-Gray Silt Loam in northern Illinois altho there are several fields on this soil type in the southern part of the state. The Antioch field is located on the late Wisconsin glaciation, in Lake county, close to the Wisconsin border. The field was started in 1902, with but a single series of ten plots, under a rotation of corn, corn, oats, and wheat; but beginning with 1911 the rotation has been wheat, corn, oats, and

Lime applied and residues plowed under — Lime and phosphorus applied

FIG. 4.—CLOVER IN 1913 ON ANTIOCH FIELD

clover. It was started in order to learn as quickly as possible what effect would be produced by the addition to this type of soil of nitrogen, phosphorus, and potassium, used singly and in combination. These elements were all applied in commercial form until 1911, after which the use of commercial nitrogen was discontinued and crop residues were substituted in its place. Nitrogen was supplied in the earlier years in 800 pounds of dried blood per acre. Phosphorus is applied in 200 pounds of steamed bone meal, and potassium in 100 pounds of potassium sulfate. At the beginning, 470 pounds of slaked lime was applied; but since 1912 limestone has been applied at the rate of 1,000 pounds per acre per year.

Table 7 presents, in summarized form, the results with the grain crops from the Antioch field. Because of an abnormality in Plot 1, the results from this plot

TABLE 7.—ANTIOCH FIELD: YELLOW-GRAY SILT LOAM, TIMBER SOIL; LATE WISCONSIN GLACIATION

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *8 crops*	Oats *5 crops*	Wheat *5 crops*
1	0	23.9	32.3	14.7
2	L	21.3	26.8	13.3
3	LR	21.3	29.9	18.9
4	LP	30.7	43.6	35.0
5	LK	23.7	27.8	17.8
6	LRP	33.8	43.3	32.6
7	LRK	24.3	26.9	19.1
8	LPK	25.1	38.2	30.3
9	LRPK	38.3	42.6	28.1
10	RPK	38.4	44.7	31.0

are not considered. The data show that phosphorus is the one element standing out prominently as producing consistently beneficial results. Potassium applied in addition to phosphorus has, on the whole, not produced profitable results. Also, the results are unfavorable for the application of limestone. Limestone, however, is abundant in the subsoil of this type in the region of this field.

DUNE SAND

In 1913 the University came into possession of a tract of Dune Sand, Terrace, in Henderson county, near the Mississippi river, upon which an experiment field was laid out to determine the needs of these sand soils. This field is divided into six series of plots. Corn, soybeans, wheat, sweet clover, and rye, with a catch crop of sweet clover seeded in the rye on the residues plots, are grown in rotation on five series, while the sixth series is devoted to alfalfa. When sweet clover seeded in the wheat fails, cowpeas are substituted.

No catch of alfalfa or of sweet clover was obtained till the alfalfa drill was used in seeding. With this implement the seed is covered about one-half inch deep.

Table 8 indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 53.

The data make apparent the remarkably beneficial action of limestone on this sand soil. Where limestone has been used in conjunction with crop residues, the yield of corn has been doubled. The limestone has also produced good crops of rye and fair crops of sweet clover and alfalfa.

This land appears to be quite indifferent to treatment with rock phosphate. The analyses show, however, that the stock of phosphorus in this type of soil is not large, and it may develop as time goes on and the supply diminishes along with the production of good-sized crops, that the application of this element will become profitable. It is also quite possible that a more available form of phosphate could be used to advantage on this very sandy soil.

Altho the results show an increase of 3.5 bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment.

Manure
Yield: Nothing

Manure and limestone
Yield: 4.43 tons per acre

FIG. 5.—ALFALFA ON OQUAWKA FIELD IN 1918

The slight increase appearing in the other crops can scarcely be considered significant.

Experience thus far shows rye to be better adapted to this land than wheat, and both alfalfa and sweet clover thrive better than soybeans. With these two

TABLE 8.—OQUAWKA FIELD: DUNE SAND, TERRACE

Average Annual Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn	Soy-beans	Wheat	Sweet Clover *6 crops*[1]		Rye	Alfalfa
		8 crops	*7 crops*	*8 crops*	*4 hay crops*	*2 seed crops*	*6 crops*	*5 crops*
1	0............	17.8	(.88)	6.8	(.00)	.00	11.6	(.16)
2	M............	22.1	(1.02)	9.4	(.00)	.00	12.7	(.26)
3	ML...........	28.3	(1.33)	12.7	(1.20)	.86	21.1	(1.76)
4	MLP..........	26.9	(1.28)	13.0	(1.26)	.75	19.9	(1.97)
					2 hay crops	*4 seed crops*		
5	0............	17.4	5.5	9.0	(.00)	.00	12.0	(.08)
6	R............	19.3	5.5	9.7	(.00)	.00	13.0	(.07)
7	RL...........	34.8	8.4	11.9	(1.47)	1.51	23.5	(1.78)
8	RLP..........	34.1	8.8	12.8	(1.39)	1.40	24.3	(1.69)
9	RLPK.........	37.6	8.5	11.7	(1.53)	1.71	24.6	(1.83)
10	0............	14.9	(.61)	7.5	(.00)	.00	11.2	(.04)

[1]In 1918 sweet clover was killed by being cut for hay. Soybeans were seeded on these plots and the following yields obtained: .86, 1.10, 1.93, and 2.00 tons of hay per acre on Plots 1 to 4; 11.1, 9.9, 14.6, 15.8, and 16.6 bushels of seed per acre on Plots 5 to 9; and .62 ton of hay per acre on Plot 10.

legume crops thriving so well under this simple treatment, we have promise of great possibilities for the profitable culture of this land, which hitherto has been considered as practically worthless.

Deep Peat

The results secured on the Manito experiment field which was located on Deep Peat and which was in operation during the years 1902 to 1905, inclusive, are presented in Table 9.

There were ten plots receiving the treatments indicated in the table. 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 total 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). It is interesting to note 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 9.—MANITO FIELD: DEEP PEAT

Corn Yields—Bushels per acre

Plot No.	Soil treatment for 1902	Corn 1902	Corn 1903	Soil treatment for 1904	Corn 1904	Corn 1905
1	None	10.9	8.1	None	17.0	12.0
2	None	10.4	10.4	Limestone, 4000 lbs.	12.0	10.1
3	Kainit, 600 lbs.	30.4	32.4	Limestone, 4000 lbs.; Kainit, 1200 lbs.	49.6	47.3
4	Kainit, 600 lbs.; Acidulated bone, 350 lb.	30.3	33.3	Kainit, 1200 lbs.; Steamed bone, 395 lbs.	53.5	47.6
5	Potassium chlorid, 200 lbs.	31.2	33.9	Potassium chlorid, 400 lbs.	48.5	52.7
6	Sodium chlorid, 700 lbs.	11.1	13.1	None	24.0	22.1
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
9	Kainit, 300 lbs.	26.4	25.1	Kainit, 300 lbs.	41.5	32.9
10	None	[1]	14.9	None	26.0	13.6

[1]No yield was taken in 1902 because of a misunderstanding.

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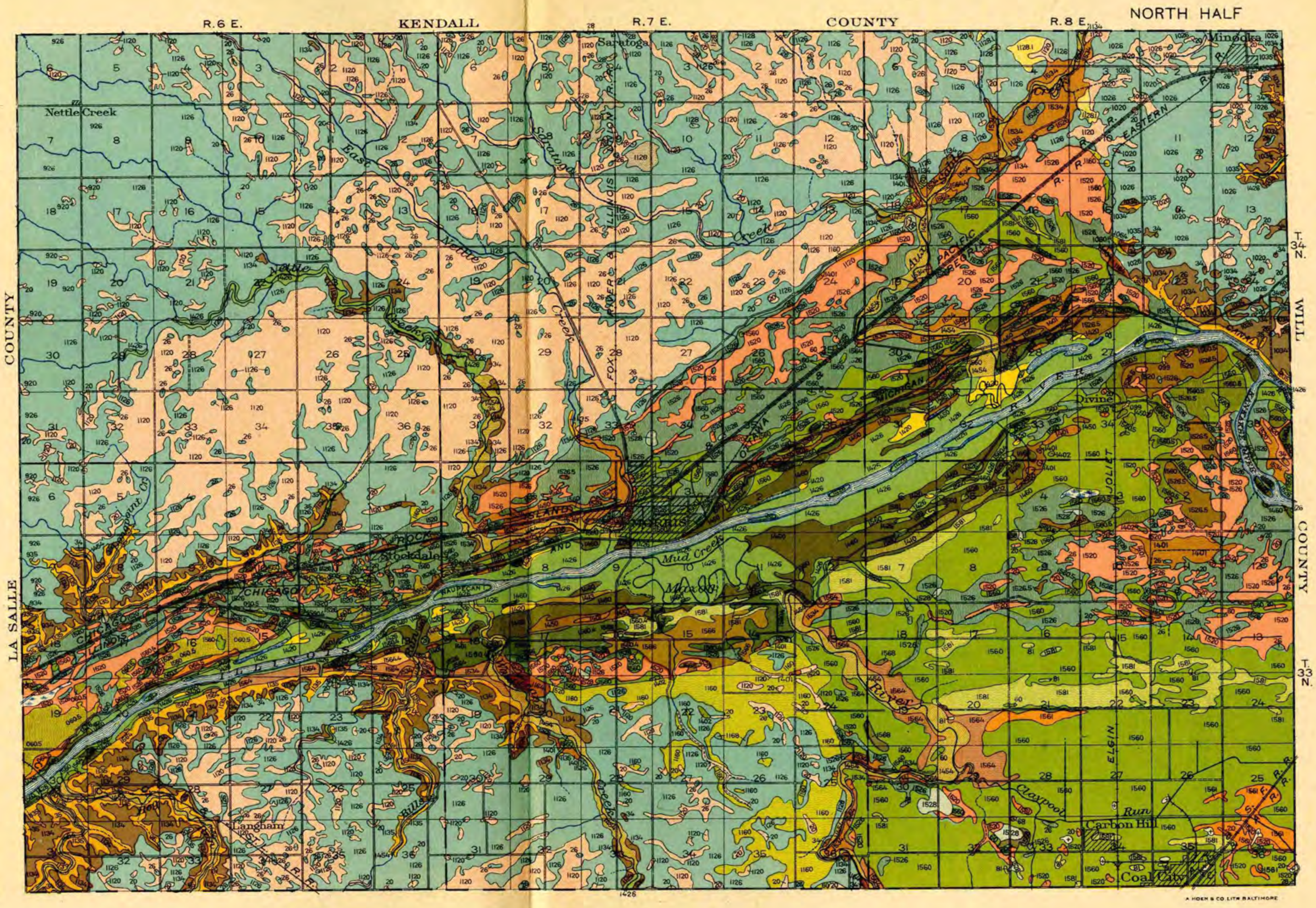


LEGEND

900 Early Wisconsin Moraines

1000 Late Wisconsin Moraines

1100 Early Wisconsin Intermorainal Areas

(a) UPLAND PRAIRIE SOILS

- 26 Brown silt loam
- 20 Black clay loam
- 60 Brown sandy loam
- 28.1 / 1128.1 Brown silt loam on tight clay
- 28 / 1128 Brown-gray silt loam on tight clay
- 68 / 1168 Brown-gray sandy loam on tight clay
- 22.1 / 1122.1 Brown-gray clay loam on tight clay
- 11604 Brown sandy loam on gravel

(b) UPLAND TIMBER SOILS

- 34 Yellow-gray silt loam
- 35 Yellow silt loam
- 64 Yellow-gray sandy loam
- 81 Dune sand

(c) 1500 TERRACE SOILS

- 26 / 1526 Brown silt loam
- 20 / 1520 Black clay loam
- 60 / 1560 Brown sandy loam
- 34 / 1534 Yellow-gray silt loam
- 64 / 1564 Yellow-gray sandy loam
- 28 / 1528 Brown-gray silt loam on tight clay
- 68 / 1568 Brown-gray sandy loam on tight clay
- 81 / 1581 Dune sand
- 61 / 1561 Black sandy loam
- 605 / 15605 Brown sandy loam on rock
- 265 / 15265 Brown silt loam on rock
- 66 / 1566 Brown sandy loam over gravel
- 644 / 15644 Yellow-gray sandy loam on gravel
- 604 / 15604 Brown sandy loam on gravel

(d) 1400 LATE SWAMP AND BOTTOM-LAND SOILS

- 26 / 1426 Deep brown silt loam
- 54 / 1454 Mixed loam
- 20 / 1420 Black clay loam
- 60 / 1460 Brown sandy loam
- 1450 Black mixed loam
- 1410 Peaty loam on clay
- 1402 Medium peat on clay
- 1401 Deep peat
- 1413 Muck on clay
- 14136 Muck on marl

Swamp

Mine dumps

Scale 0 ¼ ½ 1 2 Miles

(e) 000 RESIDUAL SOILS

- 0605 Brown sandy loam on rock
- 0645 Yellow-gray sandy loam on rock
- 099 Rock outcrop

SOIL SURVEY MAP OF GRUNDY COUNTY
UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

LEGEND

900 Early Wisconsin Moraines

1000 Late Wisconsin Moraines

1100 Early Wisconsin Intermorainal Areas

(a) UPLAND PRAIRIE SOILS

- 26 Brown silt loam
- 20 Black clay loam
- 60 Brown sandy loam
- 28.1 / 1128.1 Brown silt loam on tight clay
- 28 / 1128 Brown-gray silt loam on tight clay
- 68 / 1168 Brown-gray sandy loam on tight clay
- 22.1 / 1122.1 Brown-gray clay loam on tight clay
- 11604 Brown sandy loam on gravel

(b) UPLAND TIMBER SOILS

- 34 Yellow-gray silt loam
- 35 Yellow silt loam
- 64 Yellow-gray sandy loam
- 81 Dune sand

(c) 1500 TERRACE SOILS

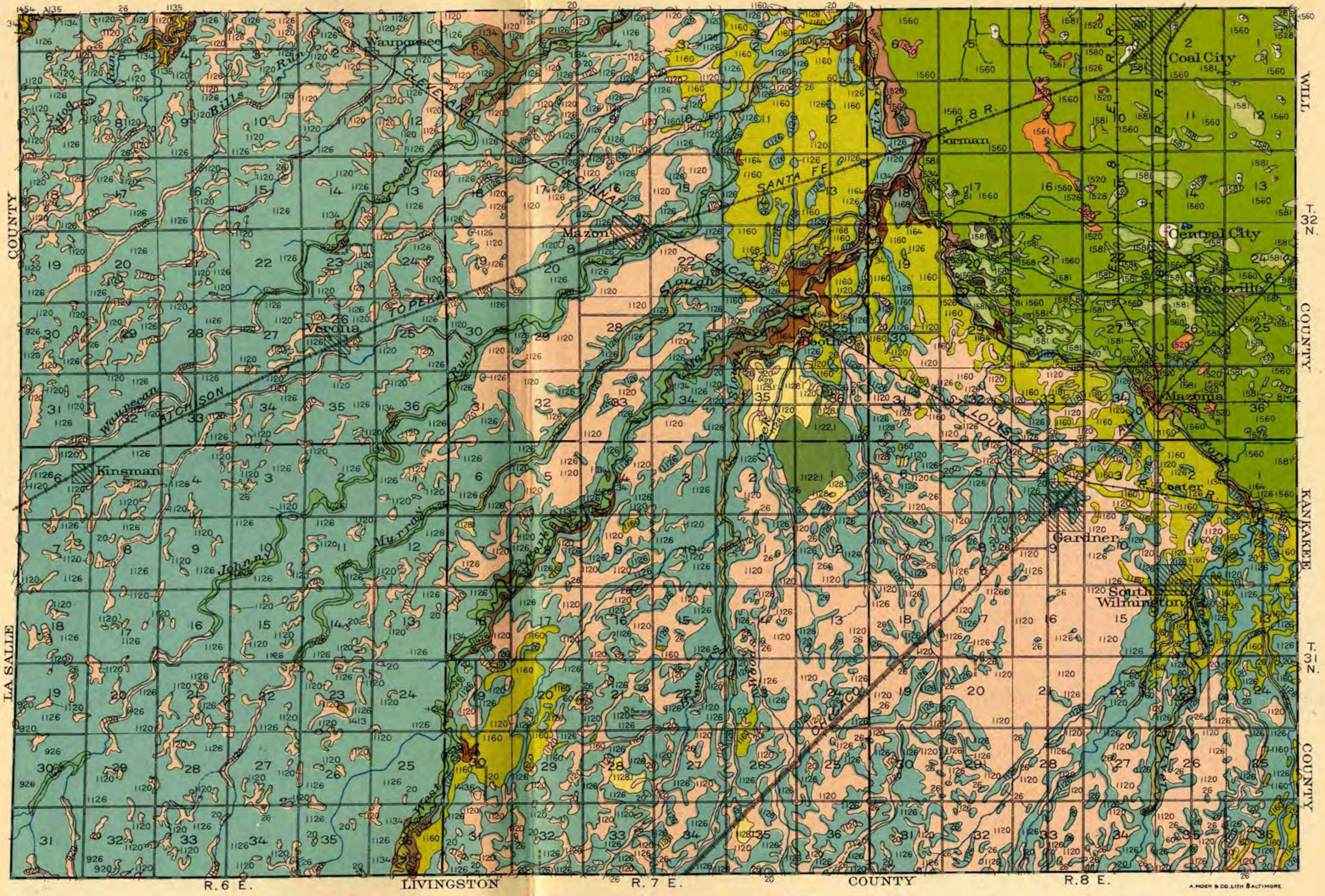
- 26 / 1526 Brown silt loam
- 20 / 1520 Black clay loam
- 60 / 1560 Brown sandy loam
- 34 / 1534 Yellow-gray silt loam
- 64 / 1564 Yellow-gray sandy loam
- 28 / 1528 Brown-gray silt loam on tight clay
- 68 / 1568 Brown-gray sandy loam on tight clay
- 81 / 1581 Dune sand
- 61 / 1561 Black sandy loam
- 60.5 / 1560.5 Brown sandy loam on rock
- 26.5 / 1526.5 Brown silt loam on rock
- 66 / 1566 Brown sandy loam over gravel
- 64.4 / 1564.4 Yellow-gray sandy loam on gravel
- 60.4 / 1560.4 Brown sandy loam on gravel

(d) 1400 LATE SWAMP AND BOTTOM-LAND SOILS

- 26 / 1426 Deep brown silt loam
- 54 / 1454 Mixed loam
- 20 / 1420 Black clay loam
- 60 / 1460 Brown sandy loam
- 1450 Black mixed loam
- 1410 Peaty loam on clay
- 1402 Medium peat on clay
- 1401 Deep peat
- 1413 Muck on clay
- 1413.6 Muck on marl
- Swamp
- Mine dumps

(e) 000 RESIDUAL SOILS

- 060.5 Brown sandy loam on rock
- 064.5 Yellow-gray sandy loam on rock
- 099 Rock outcrop



Scale 0 ¼ ½ 1 2 Miles

SOIL SURVEY MAP OF GRUNDY COUNTY
UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION