UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 36

WOODFORD COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER, AND L. H. SMITH

URBANA, ILLINOIS, JUNE, 1927

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 landowner 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 landowner 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 the 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 Woodford county was conducted, and Mr. F. A. Fisher who, as leader of the field party, was in direct charge of the mapping.

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SUPPLEMENT

WOODFORD COUNTY SOILS

By R. S. SMITH, E. E. DeTURK, F. C. BAUER, and L. H. SMITH[1]

LOCATION AND CLIMATE OF WOODFORD COUNTY

Woodford county is located in the north-central part of Illinois. It is a medium-sized county, covering 531.62 square miles, the major portion of which is made up of dark-colored upland soil.

The climate of Woodford county is typical of the general region in which it lies. It is characterized by a wide range between the extremes of winter and summer and by an abundant, well-distributed rainfall. The greatest range in temperature for any one year from 1913 to 1924 is 127 degrees in 1914. The highest temperature recorded was 107° in 1916; the lowest, 24° below zero in 1924. The average date of the last killing frost in the spring is May 4; the earliest in the fall, October 10. The average length of the growing season is 159 days.

The average annual rainfall as recorded at Minonk from 1913 to 1924 was 32.03 inches. The average rainfall by months for this period was as follows: January, 1.28 inches; February, 1.16; March, 2.29; April, 3.11; May, 3.89; June, 4.24; July, 2.80; August, 3.81; September, 3.33; October, 2.66; November, 1.79; December, 1.67.

AGRICULTURAL PRODUCTION

Woodford county is one of the leading agricultural counties of the state. Slightly over 65 percent of the area of the county is productive, dark-colored soil, making it a typical corn-belt county. According to the Fourteenth Census of the United States, there were 1900 farms in the county in 1919. The number of farms shows a decrease of about 12 percent during the last two decades. In 1919 about 54 percent of the farms were operated by tenants. There has been practically no change in the percentage of tenancy in the county during the last two decades.

The principal crops are corn and oats with an increasing acreage of the clovers and alfalfa. The following table shows the acreage and yield of the more important crops for 1919.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	94,802	4,112,186 bu.	43.4 bu.
Oats	72,524	2,235,263 bu.	30.8 bu.
Wheat	16,488	320,314 bu.	19.4 bu.
Rye	2,080	25,040 bu.	12.0 bu.
Timothy	4,325	5,912 tons	1.37 tons
Timothy and cloved mixed	5,573	8,125 tons	1.46 tons
Clover	8,140	12,084 tons	1.48 tons
Alfalfa	790	2,148 tons	2.72 tons
Silage crops	1,298	9,568 tons	7.37 tons

[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.

The U. S. Department of Agriculture reports the following average acre yields for the ten-year period 1911-1920: corn, 40.7 bushels; oats, 41.1 bushels; tame hay, 1.22 tons; winter wheat, 21.0 bushels. Thus it appears that the season of the Census year 1919 was fairly representative for the principal crops except for the oats, the yield of 30.8 bushels given for this crop being far too low to represent the average.

Woodford county gives more attention to grain farming than to livestock. The following figures taken from the 1920 Census show the character of the livestock interests in Woodford county.

Animals and Animal Products	*Number*	*Value*
Horses	13,593	$1,348,978
Mules	542	62,500
Beef cattle	13,371	787,089
Dairy cattle	11,722	728,740
Sheep	4,436	60,926
Swine	39,309	821,149
Poultry	219,793	204,177
Eggs and chickens	......	520,028
Dairy products	......	255,855

SOIL FORMATION

GEOLOGICAL ASPECTS

One of the most important periods in the geological history of the county, from the standpoint of soil formation, was the Glacial period, during which and immediately following, the material that later formed the mineral portion of the soils was being deposited. During the Glacial period, great ice sheets moved southward from the centers of accumulation in Labrador, in the Hudson Bay region, and in the northern Rocky mountains. At least six great ice movements took place, each of which covered a part of northern United States, altho the same parts were not covered during each advance.

Two of these great glacial advances, the Illinoisan and early Wisconsin, covered the area that now constitutes Woodford county. The glacial debris, known as till or drift, deposited by the Illinoisan ice sheet, was buried by the debris deposited by the more recent early Wisconsin ice sheet. Altho the Illinoisan drift does not enter into the composition of the soils of Woodford county, yet the Illinoisan glaciation probably had an important relation to the agricultural value of the soils of this county in that it acted as a leveling force, rubbing down the preglacial hills and filling the preglacial valleys. Information collected by the State Geological Survey from the few well borings available indicates that the drift extends to a depth of 125 to 150 feet over most of the county.

The soils of Woodford county are of glacial origin. Those in the northeastern part of the county are derived largely from glacial till and are known as drift soils, while those in the western and southern part of the county are derived from loess and are known as loessial soils.

The separation between the loess and drift areas can be indicated by a general line starting just north of Kappa, taking a westerly and northerly direction, swinging around to the east and north of Secor, then taking a northwesterly direction, swinging around south and west of Cazenovia, and then taking a northeasterly direction, leaving the county at about the center of Section 6, Township 28 North, Range 1 East. This line of separation between the loess and drift areas is not shown on the soil map but can readily be sketched in from the above delineation.

There is a close relation between the width of the bottom land along the Illinois river and the depth and extent of the loess on the adjacent upland. In the northwest corner of the county, the Illinois bottom is wide and to the east of this tract the loess is deeper than anywhere else in the county, reaching a depth of over 11 feet in the region of Washburn. In the vicinity of Metamora, the loess is about 8 feet deep and it gradually thins out to about 5 feet in depth in the region of Secor, Congerville, and Kappa. The extension of the loess to the eastward in the southern part of the county is apparently associated with the bottom land along the Mackinaw river and the extensive terrace formation in southern Tazewell and northern Mason counties.

The character of the soil has been strongly influenced by the character of its parent material. That a difference between the loess and drift areas exists is evident even to the casual observer from the difference in sweet clover growth along the roadsides. Carbonates occur at a depth of 30 to 40 inches in the drift area, while in the loess area no effervescence with acid occurs until a depth of from five to six feet is reached. The subsoil in the loess area is much more permeable than in the drift area, and the lime material was in a much more finely divided condition at the time the soil material was deposited, consequently leaching took place more rapidly and has progressed to a greater depth.

Limestone Outcrops

Altho a consideration of the rock formation does not lie within the province of this soil survey report, a bit of information concerning the presence of available limestone in Woodford county is inserted at this point because of its direct agricultural interest.

According to Bulletin No. 46 of the Illinois State Geological Survey, limestone of Pennsylvanian age is reported as occurring in Woodford county as follows:

Three feet of compact stone occur about 4 miles northwest of Metamora in Section 1, Township 27 North, Range 3 West, along Partridge creek.

Limestone 8 to 12 feet thick, bluish gray in color, may be found in a small quarry southwest of Secor in Sections 23 and 24, Township 26 North, Range 1 East.

Stone similar to preceding is found in a small quarry in Section 33, Township 26 North, Range 1 East.

PHYSIOGRAPHY AND DRAINAGE

The general topography of the upland in Woodford county is undulating. Rolling topography is found only in belts along the main drainage channels, and on the moraines, particularly on the Bloomington moraine which crosses the southwestern part of the county. Erosion has caused the rolling topography along streams. The slopes are steep near the Illinois river bluff, and in places along the Mackinaw river channel. The topography in the terrace area is undulating, except for the rolling sand dune formations. The altitudes of some of the places

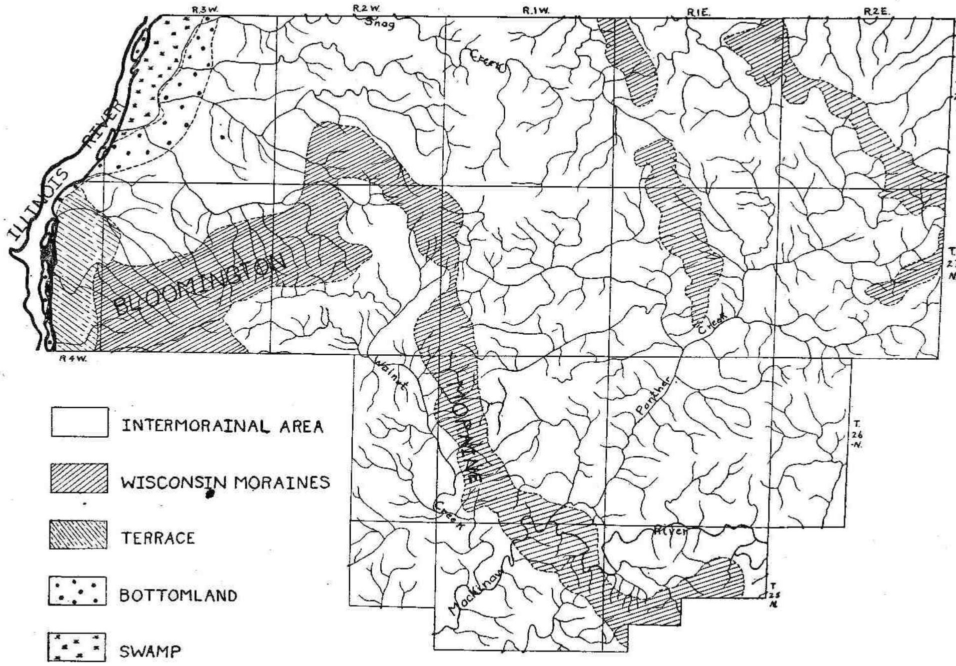

FIG. 1.—DRAINAGE MAP OF WOODFORD COUNTY SHOWING STREAM COURSES, AND MORAINAL, INTERMORAINAL, TERRACE, SWAMP, AND BOTTOM-LAND AREAS

in Woodford county are as follows: Benson, 765 feet above sea level; Cazenovia, 774; El Paso, 751; Eureka, 739; Goodfield, 748; Kappa, 773; Metamora, 814; Minonk, 745; Roanoke, 722; Secor, 744; Spring Bay, 490; Washburn, 695. The Illinois river valley lies some 200 feet below the general upland level.

The entire county lies in the Illinois river basin. The central and eastern parts of the county do not drain directly into the river, however. Drainage in the northeastern corner of Minonk township (Township 28 North, Range 2 East) is northeast to Vermilion river, thence north to the Illinois. The central and southern parts of the county are drained by Mackinaw river thru its two main tributaries, Walnut and Panther creeks. Mackinaw river flows southwest, emptying into the Illinois about 30 miles south of the county.

There were many shallow ponds, swamps, and poorly drained areas in the central and eastern parts of the county prior to its settlement. Artificial drainage, principally tiling and deepening of the small ditches, removed this excess water so that now these areas can be farmed. Except for the swampy overflow land next to Illinois river, both the surface drainage and underdrainage of the whole county are good.

SOIL DEVELOPMENT

During the time which has elapsed since the last ice invasion, weathering and other processes have been active, resulting in the formation of the soils of the county as we know them today. When first deposited the general composition of any soil material, particularly loess, is rather uniform but with the passing of time various physical chemical, and biological agencies of weathering form soil out of the parent material by some or all of the following processes: the leaching of certain elements, the accumulation of others; the chemical reduction of certain compounds, the oxidation of others; the translocation of the finer soil particles, and the arrangement of them into zones, or "horizons"; the accumulation of organic matter from the growth and decay of vegetable material. One of the very pronounced characteristics observed in most soils is that they are composed of more or less distinct strata, called horizons. As explained somewhat more fully in the Appendix, these horizons are named, from the surface down: A, the layer of extraction; B, the layer of concentration or accumulation; and C, less-altered material, or the layer in which weathering has had less effect. The development of horizons in a soil is an indication of its age.

Since the upland prairie of this region has been occupied, probably continuously, by grass vegetation, relatively large amounts of organic matter have accumulated, resulting in the formation of productive dark-colored soils. The areas adjacent to streams, which have been occupied by timber, are light-colored because of the relative deficiency of the surface soil in organic matter. The bottom-land soils are made up, for the most part, of alluvial material brought down from the uplands of the immediate vicinity. These soils are to be regarded as relatively young or immature and therefore have not developed horizons as have the mature soils of the upland.

SOIL GROUPS

The soils of Woodford county are divided into four groups, as follows:

Upland Prairie Soils, including the dark-colored upland soils.

Upland Timber Soils, including the light-colored upland soils.

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

Terrace Soils, including alluvial deposits now above overflow.

Table 1 gives the area of each soil type in Woodford county and its percentage of the total area. It will be observed that 66.32 percent of the county consists of upland prairie, 22.29 percent of upland timber, 1.79 percent of terrace soils, 6.53 percent of bottom-land soils, and 3.09 percent grouped as miscellaneous, including river, swamp, mine dumps, and gravel pits. The accompanying map, appearing in two sections, shows the location and boundary lines of the various soil types.

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

TABLE 1.—SOIL TYPES OF WOODFORD COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Upland Prairie Soils (900, 1100)			
926, 1126	Brown Silt Loam[1]	310.29	198 586	53.38
920, 1120	Black Clay Loam	42.29	27 066	7.95
1128	Brown-Gray Silt Loam On Tight Clay	.04	26	.01
		352.62	225 678	66.32
	Upland Timber Soils (900, 1100)			
934, 1134	Yellow-Gray Silt Loam	67.86	43 430	12.77
935, 1135	Yellow Silt Loam	49.58	31 731	9.31
1181	Dune Sand	.97	621	.18
		118.41	75 782	22.29
	Swamp and Bottom-Land Soils (1400)			
1401	Deep Peat	.60	384	.11
1426	Brown Silt Loam	2.29	1 465	.42
1454	Mixed Loam	31.76	19 607	5.98
1460	Brown Sandy Loam	.11	70	.02
		34.76	22 246	6.53
	Terrace Soils (1500)			
1527	Brown Silt Loam Over Gravel	2.22	1 421	.42
1526.4	Brown Silt Loam On Gravel	.15	96	.02
1566	Brown Sandy Loam Over Gravel	.20	128	.04
1560.4	Brown Sandy Loam On Gravel	1.79	1 146	.33
1536	Yellow-Gray Silt Loam Over Gravel	2.87	1 837	.54
1567	Yellow-Gray Sandy Loam Over Gravel	.48	307	.09
1580	River Sand	1.70	1 088	.33
		9.41	6 023	1.77
	Miscellaneous			
	River	7.53	4 819	1.42
	Swamp	8.84	5 657	1.66
	Mine Dumps	.03	19	.006
	Gravel pits	.02	13	.004
		16.42	10 508	3.09
	Total	531.62	340 237	100.00

[1] Including associated types described in the text but not differentiated on the map.

INVOICE OF THE ELEMENTS OF PLANT FOOD IN WOODFORD 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 million 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 horizons A, B, and C (see page 24). By this system of sampling we have represented separately three zones for plant feeding. The surface layer includes at least as much soil as is ordinarily turned with the plow, 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. It should be understood, however, that the rate of liberation from their insoluble forms, a matter of at least equal importance, is governed by many factors, and is therefore not necessarily proportional to the total amounts present.

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 doing 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 million pounds. 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 purpose intended. It is, of course, a simple matter to convert these figures back to the percentage basis in case one desires to consider the information in that form.

With respect to the presence of limestone and acidity in different strata, no attempt is made to include in the tabulated results figures purporting to represent their averages for the respective types, because of the extreme variations frequently found within a given soil type. In examining each soil type in the field, however, numerous qualitative tests are made which furnish general information regarding the soil reaction, and in the discussion 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 and soil treatment. It is often desirable, therefore, 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 31).

THE UPPER SAMPLING STRATUM

In Table 2 are reported the amounts of organic carbon, nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in 2 million pounds of the surface soil of each type in Woodford county.

In connection with this table attention is called to the variation among the soil types with respect to their content of the different plant-food elements. It will be seen from the analyses that variations in the organic-carbon content of the different soils are accompanied by similar variations in the nitrogen content. The organic carbon content, which serves as a measure of the total organic matter present, is usually from 10 to 12 times that of the total nitrogen. This relationship is explained by the well-established facts that all soil organic matter contains nitrogen, and that most of the soil nitrogen (usually 98 percent or more) is present in a state of organic combination. This close relationship is also maintained in the middle and lower sampling strata.

Woodford county soils have a wide range in content of organic-matter and nitrogen. The upland prairie soils are for the most part relatively high in these constituents. The upland timber soils are generally fairly low, whereas the swamp, bottom-land, and terrace soils show extreme variations. The sand soils are the lowest of all, regardless of where they occur. Thus the upland Dune Sand contains but 5,480 pounds an acre of organic carbon and 680 pounds of nitrogen. The River Sand of the terrace is somewhat higher in organic carbon, but is much below the types of finer texture. Dune Sand is, in fact, but little more than the skeleton of a soil and cannot by any practical means be brought up to a state of productiveness without first getting an accumulation of organic matter in it, and continuing with subsequent additions. The soil is usually acid and hence limestone and legume green manures constitute the first and most important step in converting it into a productive soil.

Black Clay Loam has more organic carbon in the upper layer than any other soil in the county except Deep Peat, which is made up largely of organic matter. The organic carbon of the Black Clay Loam amounts to 82,510 pounds an acre, with a corresponding nitrogen content of 7,070 pounds. While such soils as this will withstand more abuse by the practice of "soil robbing" methods of farming and are not so greatly in need of additions of organic materials as are soils containing 20,000 to 30,000 pounds of organic carbon, yet the use of manure and the systematic growing of legumes for pasture and plowing down serve to renew the active organic material in the soil in a way which is reflected in increases of crop yields. Excluding Dune Sand, discussed above, the upland timber soils of Woodford county average only 26,260 pounds of organic carbon and 2,260 pounds of nitrogen an acre in the surface 2 million pounds of soil, as compared with 62,850 and 5,170 pounds of these two elements respectively in the upland prairie soils.

Other constituents are not so closely associated with each other as organic matter and nitrogen. However, there is some degree of correlation between sulfur, another element used by growing plants, and organic carbon. This is because a considerable, tho varying, proportion of the sulfur in the soil exists in the organic form, that is, as a constituent of the organic matter.

Most of the Woodford county soils are fairly well supplied with sulfur. It ranges, in the surface soil, from the very low figure of 160 pounds to 5,900 pounds an acre. With the exception of Deep Peat, which contains a very large amount of sulfur, the sulfur content amounts to between one-half and two-thirds that of phosphorus. The sulfur available to crops is affected not only by the soil supply, but also by that brought down from the atmosphere by rain. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous sulfur dioxid is soluble in water and consequently it is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption the amount of sulfur thus added to the soil is relatively large. At Urbana, during the eight-year period from 1917 to 1924, there was added to the soil by the rainfall, 3.5 pounds of sulfur an acre as a monthly average. Similar observations have been made in other localities for shorter periods. At Carlinville, in Macoupin county, the rainfall for seven months, April to October, 1922, brought down 34.85 pounds of sulfur an acre, or an average of 5 pounds a month. At Toledo, Cumberland county, from April to November, 1922, the average precipitation was 3 pounds an acre a month. The precipitation at the various points in the state in a single month has varied from a minimum of .74 of a pound to 10.22 pounds an acre.

The above figures will afford some idea of the amount of sulfur added by rain and also of the wide variation in these amounts under different conditions. On the whole, these facts would indicate that the sulfur added from the atmosphere supplements that contained in the soil, so that for the most part there is probably no need for sulfur fertilizers in Woodford county. In order to determine definitely the response of crops to applications of sulfur fertilizers, experiments with gypsum have been started at five experimental fields; namely, Raleigh, Toledo, Carthage, Hartsburg, and Dixon.

The upland timber soils are deficient in phosphorus, the amounts in the surface soil ranging from 320 pounds to 800 pounds per 2 million pounds of soil. River Sand and Yellow-Gray Silt Loam Over Gravel in the terrace are likewise deficient. These deficiencies would indicate the probable need for phosphate fertilization on these soils, as mentioned in the discussion of these types. The rest of the soil types in the county are fairly well supplied with total phosphorus.

Deep Peat, as is usually the case, is deficient in potassium, there being only 6,880 pounds in the surface 6⅔-inch stratum. Other types, excepting Dune Sand and River Sand, contain rather more potassium than is usually the case, the average, eliminating these low types, being 44,530 pounds per 2 million pounds of soil. The sand soils, while containing a total amount of potassium which should be sufficient for crop production, carry a large proportion of it in the coarse sand grains. The relatively small surface exposed in the case of the coarse particles greatly lowers the solubility and availability of the potassium in sand soils. This is partly offset, however, by the greater depth of the feeding zone for crop roots in sandy soils as compared with the heavier types.

Both calcium and magnesium are fairly well supplied in the soils of Woodford county. The supply of calcium in the upper 6⅔ inches of soil ranges from 5,920 to 72,170 pounds, and the supply of magnesium from 2,340 to 18,860 pounds.

THE MIDDLE AND LOWER SAMPLING STRATA

In Tables 3 and 4 are recorded the amounts of the plant-food elements in the middle and lower sampling strata. In comparing these strata with the upper stratum, or with each other, it is necessary to bear in mind that the data as given for the middle and lower sampling strata are on the basis of 4 million and 6 million pounds of soil, and should therefore be divided by two and three respectively before comparing them with each other or with the data for the upper stratum, which is on a basis of 2 million pounds.

Considering the data in this way and comparing the three strata with each other, it will be noted that some of the elements remain practically constant in amount thruout the entire depth sampled. Others exhibit more or less marked variation at the different levels. Furthermore, these variations usually go in certain general directions, and by a careful study of them it is frequently possible to obtain clues as to the age or stage of maturity of the various soils, the agricultural importance and needs, and the nature of the processes going on in soil formation.

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF WOODFORD 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
	Upland Prairie Soils (900, 1100)							
926, 1126	Brown Silt Loam	57 410	4 450	1 020	1 410	43 440	7 240	10 730
1120	Black Clay Loam	82 510	7 070	2 030	1 400	45 770	11 250	39 810
1128	Brown-Gray Silt Loam On Tight Clay	48 640	3 980	1 000	680	50 920	6 030	10 680
	Upland Timber Soils (900, 1100)							
934, 1134	Yellow-Gray Silt Loam	29 900	2 530	800	610	48 450	4 860	9 170
1135	Yellow Silt Loam	22 620	1 990	690	380	51 010	8 160	13 820
1181	Dune Sand	5 480	680	320	180	31 420	9 540	6 520
	Swamp and Bottom-Land Soils (1400)							
1401	Deep Peat[1]	309 860	27 700	1 020	5 900	6 880	6 330	72 170
1426	Brown Silt Loam	49 240	4 180	1 680	600	51 340	18 860	27 820
1454	Mixed Loam[2]	......	......	......	......	......	......	......
1460	Brown Sandy Loam	27 180	2 280	1 220	320	39 600	15 980	30 500
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	51 730	4 030	1 490	790	44 780	8 010	11 010
1526.4	Brown Silt Loam On Gravel	33 200	2 720	1 300	620	34 800	6 820	9 270
1566	Brown Sandy Loam Over Gravel	24 120	2 040	700	400	44 740	4 260	8 800
1560.4	Brown Sandy Loam On Gravel	42 240	3 790	1 580	870	31 900	8 620	9 830
1536	Yellow-Gray Silt Loam Over Gravel	21 580	1 800	730	360	40 260	3 960	7 360
1580	River Sand	10 620	760	460	160	29 960	2 340	5 920

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]Amounts reported for Deep Peat are for 1 million pounds of soil.

[2]On account of the heterogeneous character of Mixed Loam, chemical data are not included for this type.

With the exception of Deep Peat all of the soil types diminish rather rapidly in organic matter and nitrogen with increasing depth, and this diminution is very marked even in the middle stratum. The sulfur content decreases markedly with increasing depth except in the case of Deep Peat. This is to be expected since a portion of the sulfur exists in combination with the soil organic matter, and inorganic forms of sulfur are not tenaciously retained by the soil against the leaching action of ground water. Phosphorus, on the other hand, is not removed from the soil by leaching. It is converted by growing plants into organic forms and tends to accumulate in the surface soil in these forms in plant residues at the expense of the underlying strata. Consequently, in the majority of the soil types in Woodford county the surface soil contains a larger proportionate amount of phosphorus than the middle and lower strata.

The content of potassium in the different depths varies only slightly, but the other two important basic elements, calcium and magnesium, have undergone some shifting in the different levels, as exhibited by analyses of upland types. The calcium content, on the whole, is much higher than that of magnesium, indicating a more abundant supply of calcium in the soil-forming materials. However, with the exception of Yellow Silt Loam, which is alkaline in the middle and

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF WOODFORD 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
	Upland Prairie Soils (900, 1100)							
926, 1126	Brown Silt Loam	74 980	6 430	1 620	1 360	85 540	18 320	21 340
1120	Black Clay Loam	83 400	7 300	3 100	1 420	98 330	23 700	52 770
1128	Brown-Gray Silt Loam On Tight Clay	52 520	4 560	1 520	880	104 880	18 400	20 440
	Upland Timber Soils (900, 1100)							
934, 1134	Yellow-Gray Silt Loam	24 640	2 560	1 420	780	102 750	14 080	15 760
1135	Yellow Silt Loam	21 420	2 400	1 510	710	93 910	21 170	52 080
1181	Dune Sand	7 440	760	960	520	64 680	6 080	12 080
	Swamp and Bottom-Land Soils (1400)							
1401	Deep Peat[1]	790 300	62 200	1 620	16 760	10 340	9 420	138 760
1426	Brown Silt Loam	100 080	8 440	3 440	1 360	105 400	36 440	50 920
1454	Mixed Loam[2]	....	....	....	....	....	....	....
1460	Brown Sandy Loam	37 080	3 280	2 120	520	69 760	39 040	83 960
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	71 010	6 130	2 590	1 060	93 960	19 980	19 980
1526.4	Brown Silt Loam On Gravel	49 600	4 380	2 260	1 040	69 420	16 140	18 260
1566	Brown Sandy Loam Over Gravel	46 400	4 000	1 160	960	78 880	9 800	20 080
1560.4	Brown Sandy Loam On Gravel	66 210	4 900	2 120	1 240	66 730	17 100	15 450
1536	Yellow-Gray Silt Loam Over Gravel	22 760	2 180	1 460	620	87 140	14 540	15 240
1580	River Sand	16 720	1 200	1 040	440	55 240	6 040	12 040

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

[1]Amounts reported for Deep Peat are for 2 million pounds of soil.
[2]On account of the heterogeneous character of Mixed Loam, chemical data are not included for this type.

lower strata, carrying considerable quantities of calcium carbonate, the calcium content diminishes in the middle stratum as compared with the upper. This is accompanied by an increase in the magnesium content in both the middle and lower strata. As these two elements leach downward thru the soil, magnesium is more readily absorbed by the soil mass than calcium, thus forcing the latter out into the solution to be carried farther down. Consequently calcium does not begin to accumulate until it reaches the lowest level, and in counties farther south, with greater rainfall, it is carried down several feet or washed away entirely. The terrace soils are beginning to show the results of this process, but in the bottom-land soils these changes are completely masked by the effects of overflow.

It is frequently of interest to know the total supply of a plant-food element accessible to the growing crops. While it is not possible to obtain this information exactly, especially for the deeper rooted crops, it seems probable that practically all 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.

TABLE 4.—PLANT-FOOD ELEMENTS IN THE SOILS OF WOODFORD 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
	Upland Prairie Soils (900, 1100)							
926, 1126	Brown Silt Loam	40 260	3 750	2 020	970	136 290	42 330	44 440
1120	Black Clay Loam	31 250	3 450	3 560	1 020	148 430	39 360	63 950
1128	Brown-Gray Silt Loam On Tight Clay	33 900	3 720	2 760	780	169 680	43 860	37 980
	Upland Timber Soils (900, 1100)							
934, 1134	Yellow-Gray Silt Loam	25 500	2 490	2 270	920	153 810	37 070	28 500
1135	Yellow Silt Loam	21 440	2 240	2 180	1 020	131 760	54 080	162 700
1181	Dune Sand	7 380	840	1 500	660	81 300	10 560	15 780
	Swamp and Bottom-Land Soils (1400)							
1401	Deep Peat[1]	1 351 050	9 000	1 890	41 100	19 500	15 300	168 180
1426	Brown Silt Loam	74 700	6 360	4 140	1 260	146 460	73 680	119 100
1454	Mixed Loam[2]	......	......	......	......	......	......	......
1460	Brown Sandy Loam	30 000	2 100	2 400	900	110 880	48 420	121 680
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	58 600	5 180	3 440	1 110	138 040	42 000	30 180
1526.4	Brown Silt Loam On Gravel	54 780	5 340	3 480	2 040	97 740	42 660	28 320
1566	Brown Sandy Loam Over Gravel	36 660	3 000	1 800	840	139 560	19 980	19 200
1560.4	Brown Sandy Loam On Gravel	43 510	3 720	2 400	1 200	88 800	17 700	23 540
1536	Yellow-Gray Silt Loam Over Gravel	22 920	2 100	2 490	780	121 230	21 780	22 680
1580	River Sand	13 260	1 320	840	420	81 340	4 320	21 060

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

[1]Amounts reported for Deep Peat are for 3 million pounds of soil.
[2]On account of the heterogeneous character of Mixed Loam, chemical data are not included for this type.

Examined in this way the tables reveal that there is not only a 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 the various elements within a given soil type as measured by crop requirements. For example, in the analyses as given for Brown Silt Loam, Upland, we find that the total quantity of nitrogen in an acre to a depth of 40 inches amounts to 14,630 pounds. This is about the amount of nitrogen contained in the same number of bushels of corn. The amount of phosphorus, 4,660 pounds, contained in the same soil is equivalent to that contained in 27,410 bushels of corn, while the amount of potassium present is 265,270 pounds, the equivalent of that contained in nearly 1½ million bushels of corn. In marked contrast to this soil, with respect to nitrogen, is the Yellow Silt Loam, which contains in the 40-inch stratum approximately 6,630 pounds an acre of nitrogen, an amount equal to that in 6,630 bushels of corn. The phosphorus content is about the same as that of Brown Silt Loam, namely, 4,380 pounds in an acre, equivalent to that contained in 25,760 bushels of corn. The potassium content of the two soil types is also approximately equal. The calcium content is not of so much significance in connection with corn as with legumes. Brown Silt Loam contains in the 40-inch stratum 76,510 pounds of calcium an acre, while Yellow Silt Loam contains 228,600 pounds. Since a ton of red clover hay contains approximately 29 pounds of calcium the above amounts are equivalent, respectively, to 2,640 and 7,950 tons of clover hay. This wide variation in amounts of calcium in the two soil types is accounted for by the presence of calcium carbonate in the lower sampling stratum of Yellow Silt Loam, while in Brown Silt Loam it has been leached out to a depth greater than 40 inches. As a matter of fact, since the carbonate in the soil is largely calcium carbonate, soils showing the presence of carbonate invariably contain large quantities of calcium. For example, it has been found in examining the individual analyses of Woodford county soils that the non-carbonate soils range in calcium content from 34,000 pounds an acre up to 78,000 pounds, in the 40-inch stratum, while with the carbonate-containing soils the range is from 47,000 pounds to 592,000 pounds. Only two samples, however, fell below the 78,000-pound level.

The above 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 merely the 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 materials, 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 the plant-food elements that can possibly be drawn upon, and in this way 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 SOIL TYPES

The soil map upon which this report is based was completed in 1917. During the years which have elapsed since the survey was made, the knowledge of soils has increased very materially, particularly with reference to soil classification. At the present time several of the types shown on the map, notably Brown Silt Loam, Black Clay Loam, and Yellow-Gray Silt Loam, are each considered to include two or more types. For the purposes of this report, these types, which are now recognized but not shown on the map, will be described and their topographic position stated so that they may be recognized in the field.

UPLAND PRAIRIE SOILS

The upland prairie soils of Woodford county occupy 352.62 square miles, or 66.32 percent of the area of the county.

The dark color of prairie soils is due to the accumulation of organic matter, which is derived very largely from the fibrous roots of prairie grasses. The network of grass roots was protected from rapid and complete decay owing to the rather effective exclusion of oxygen by the covering of fine, moist soil, and by the mat of vegetative material formed by old grass stems and leaves. On the native prairies the stems and leaves of the grasses were in part burned by prairie fires or were lost in part thru decay, so that they actually added little organic matter to the soil; however, the protection afforded by this mat of constantly renewed, decaying material was of importance in retarding the decay of the roots. From a sample of virgin bluestem sod, one of the most common prairie grasses, it has been determined that an acre of this soil to a depth of 7 inches may contain as high as 13½ tons of roots.

Brown Silt Loam (926, 1126)

Brown Silt Loam, Upland, as mapped, is the most extensive type in Woodford county. The portion of the type found in the loess area, as described in the section on Geological Aspects (page 2) is markedly different from that found in the drift area. In the loessial portion of the type it is much deeper to carbonate, averaging 60 to 70 inches as compared with 30 to 40 inches in the drift area; the B horizon is less mottled, and less compact and heavy; and the C horizon is a very friable, fine sandy loam, while in the drift area it is a compact sandy and gravelly clay. The A horizon of Brown Silt Loam in the two areas, loess and drift, is not significantly different, at least in so far as characteristics which can be observed in the field are concerned.

Types of the Loess Area

In the loess area, the soil which was mapped originally as Brown Silt Loam is now separated into three types, as follows: Light Brown Silt Loam, Brown Silt Loam, and Brown Silt Loam On Clay.

Light Brown Silt Loam occurs on the higher areas and has always been well drained. The A_1 horizon, which is about 10 to 12 inches deep, is a light brown silt loam. The A_2 horizon, which extends to a depth of about 20 to 22 inches, is a slightly yellowish brown silt loam. The B horizon is a non-mottled, non-compact, reddish yellow silt loam or silty clay loam, and the C horizon is a very friable, slightly mottled, fine sandy loam, passing into highly calcareous fine sandy loam at about 60 inches.

Management.—This type is similar to the soil of a considerable portion of the Mt. Morris experiment field. On this field, manure alone has given excellent returns, and when limestone has been applied in addition to the manure, a further increase has resulted, which has been sufficiently large to pay a handsome profit on the limestone. Residues alone have increased the yields of corn and oats, but the data from this field indicate clearly that if residues and green manures are used as the chief source of nitrogen and organic matter on this soil, limestone must also be included in the system. The crop increases following the use of limestone and green manure are large, exceeding the increases following the use of stable manure and limestone. Rock phosphate has not caused sufficient increase in yield on the Mt. Morris field to pay for its cost. The reader is referred to page 42 for a further discussion of the results from this field. The available information indicates that, for the present at least, Light Brown Silt Loam should be treated with 2 to 3 tons of limestone an acre followed by the regular growth of clover, preferably sweet clover, and the application of all available manure. It is suggested that, in addition, trial be made of the phosphates for wheat. A discussion of the various phosphates will be found in the Appendix on page 34.

Brown Silt Loam occurs on positions of intermediate topographic expression. The A_1 horizon, about 10 inches deep, is a brown silt loam, passing into a somewhat heavier, light brown silt loam which frequently becomes reddish brown at about 14 inches. The B horizon begins at 20 to 22 inches, and extends to 28 to 33 inches in depth. It is a medium-mottled, yellow or yellowish brown clay loam, medium compact, and only slightly plastic. The C horizon is a mottled, pale yellow, friable silt loam with reddish brown iron concretions, and passes into fine sandy loam which becomes highly calcareous at about 60 inches.

Management.—This type is similar to the soil on the Kewanee experiment field. The results from this field (page 43) show a good response to manure alone and to residues and lime in combination. Where lime was used in addition to manure, an additional increase in yield was secured, but the increase was not so large as where lime was used in addition to residues. This behavior indicates that manure satisfies in part the same deficiency that lime satisfies on this medium-acid soil. The returns from the use of rock phosphate on this field are not such as to justify its unqualified recommendation. This is particularly true in the manure system. Where green manures were the source of nitrogen and organic matter, rock phosphate gave just about sufficient increase in yield to pay for its cost when used at the rate of one ton an acre once in the rotation. The Bloomington experiment field is located in part on this same type of soil. The results from this field (page 44), on which bone meal is the phosphate carrier used, show excellent returns for phosphorus and lead to the recommendation that one of the more soluble phosphates, steamed bone meal, acid phosphate, or basic slag, be given a trial for wheat. The reader is referred to the discussion of these materials on page 34.

Brown Silt Loam On Clay occurs on the flatter areas and was formed under conditions of intermittently poor drainage. The A_1 horizon of this type is a dark brown silt loam, sometimes showing a slightly gray cast when dry. At about 10 inches in depth the color becomes somewhat lighter and at about 18 inches it becomes distinctly yellowish brown. The B horizon begins at about 21 inches and extends to about 30 inches. It is a strongly mottled, pale yellow, compact, medium-plastic clay. The C horizon is a strongly mottled, reddish brown or yellow, friable silt loam.

Management.—The Brown Silt Loam On Clay is less acid than either of the types above described. It will usually grow red clover without lime but will not grow either sweet clover or alfalfa without the application of lime. It is better supplied with organic matter and nitrogen than either of the types above described. There is no experiment field in the state located on this soil type, consequently no definite recommendations can be made for its treatment other than the use of lime as needed and the regular return of fresh organic matter.

Types of the Drift Area

In the drift area the soil which was mapped as Brown Silt Loam is now separated into two types as follows: Brown Silt Loam On Drift and Brown Silt Loam On Calcareous Drift.

Brown Silt Loam On Drift has a brown silt loam A_1 horizon to a depth of about 8 inches and frequently contains a limited number of chert and other rock fragments. The A_2 horizon is a yellowish brown silt loam containing some rock fragments and extends to a depth of about 18 or 20 inches. The B horizon is a medium-mottled, dark yellow, sandy and gravelly clay, medium compact and slightly plastic. The C horizon is a yellow, sandy, gravelly clay loam, fairly friable, and not much compacted.

In certain portions of the county a calcareous phase of the above type occurs, to which no name has yet been assigned.

Management.—There is no experiment field located on precisely this soil type. However, with allowance for a somewhat greater lime requirement in general, it is reasonable to suppose that management methods suitable for the associated type described immediately below would apply to this type also.

Brown Silt Loam On Calcareous Drift has a darker colored A_1 horizon than the preceding type and is heavier and more strongly mottled in the B horizon. It occurs on somewhat lower ground than Brown Silt Loam On Drift and is always calcareous within the three-foot section. The A_1 horizon to a depth of about 8 inches is a dark brown silt loam. The A_2 horizon to about 15 inches in depth is a brown silt loam and then changes to a yellowish brown silt loam. The B horizon is a yellow or brownish yellow clay or clay loam, compact, medium plastic, and medium mottled. The C horizon, beginning at about 25 or 30 inches, is a mottled, brownish pale yellow, fairly compact but medium friable, highly calcareous, gravelly and sandy clay loam.

Management.—The Joliet experiment field is located on soil similar to this type. The results of experiments on this field which may be found on page 46, show excellent returns from manure and from lime used with manure, fair returns from crop residues including green manure, or from residues and lime, and excellent returns from rock phosphate, particularly in the residues system. The beneficial effect on corn from the potassium treatment suggests the use in an experimental way of one of the potash salts applied at the rate of about 100 pounds an acre to the corn crop.

Black Clay Loam (920, 1120)

Black Clay Loam occupies 42.29 square miles in Woodford county, or 7.95 percent of the area of the county. It falls naturally into two groups, one in the loess area and another in the drift area; and each of these two groups, as it occurs in this county, is now recognized to include two types.

In the loess area, this soil as now mapped would be classified as Black Clay Loam On Drab Clay, and Black Clay Loam. In the drift area, this soil as now mapped would be classified as Black Clay Loam On Drab Clay, and Black Clay Loam On Plastic Calcareous Drift.

These types are more difficult to distinguish than those described under Brown Silt Loam because their occurrence is not associated with characteristic topographic expressions. For this reason, the following generalized description of the type as it is mapped will be given instead of each type as it actually exists.

The A_1 horizon is 10 to 12 inches deep, and is a dark brown to black clay loam. The A_2 horizon usually extends to a depth of about 20 inches, is drabbish black in color, and is somewhat heavier than the A_1 horizon. It usually contains small yellow spots and in the lighter portions of the type is distinctly yellow instead of drabbish black. The B horizon in the heavier portions of the type is a gray or heavily mottled, compact, and plastic clay, while in the lighter portions it is a strongly mottled yellow, compact, medium-plastic clay or clay loam.

Management.—The primary requirement to be met in the management of Black Clay Loam as it occurs in Woodford county is the regular addition of organic matter to maintain a good physical condition. Both manure and green manures may be used for this purpose, as shown by the results secured on the Minonk and Hartsburg experiment fields. The soil of the Minonk field (page 47) is similar to the Black Clay Loam of the drift area while the soil of the Hartsburg field is more nearly like that of the loess area. There has been no response to lime on the Minonk field, indicating that this material is not needed on the Black Clay Loam of the drift area. The Hartsburg field (page 51) has shown some response to lime used with manure, but used with residues adverse results have been obtained. This apparent discrepancy emphasizes the importance of applying the acidity test to each field in order to determine the need for limestone. However, it should probably not be used in excess of about 2 tons an acre. These two fields are in agreement in showing that neither rock phosphate nor potash can be used on this soil in either of the areas with any expectation of a sufficient increase in yields to pay for the cost of the materials.

Brown-Gray Silt Loam On Tight Clay (1128)

A few very small areas, aggregating only 26 acres, of Brown-Gray Silt Loam On Tight Clay occur northeast of El Paso. This type is characterized by a grayish brown A_1 horizon, an ashy gray A_2 horizon, and a highly plastic "tight clay" B horizon.

UPLAND TIMBER SOILS

The upland timber soils occur as irregular zones along the streams. They belong to the light-colored group of soils because of 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 Woodford county occupy about 22 percent of the area of the county.

Yellow-Gray Silt Loam (934, 1134)

Yellow-Gray Silt Loam occupies 67.86 square miles, or 12.77 percent of the area of the county. Practically all of this type occurs within the loessial area and most of it in Woodford county, if mapped to-day, would be called Brownish Yellow-Gray Silt Loam in order to distinguish it from other types of light-colored upland soil which hitherto have all been classified as Yellow-Gray Silt Loam.

The A_1 horizon, which is about 5 inches deep in uncultivated areas and 7 or 8 inches in cultivated fields, is a brownish gray silt loam with laminated structure when not disturbed by cultivation. The A_2 horizon is a yellowish gray friable silt loam with laminated structure. The B horizon, which begins at a depth of about 14 inches, is a compact clay loam. It has a cubical structure, and the faces of the cubes are coated with a chocolate brown film, giving the entire mass a chocolate brown appearance. When this horizon is bored out with a soil auger, the sample is distinctly yellow. At a depth of about 23 inches strong mottling becomes evident and the texture appears to become finer. The C horizon begins at a depth of about 36 inches and is a friable, strongly mottled, yellow clay loam, with numerous black iron concretions appearing near the bottom of the 40-inch section.

Management.—Yellow-Gray Silt Loam, as it occurs in Woodford county, is of medium acidity. No effervescence with acid is obtained until a depth of about 60 inches is reached. Sweet clover does not grow along the roadsides except where deep ditches have been made in grading. The organic-matter and nitrogen contents of this soil are low. The subsoil, while fairly compact, is not plastic and permits good underdrainage, while the topography allows good surface drainage on most of the type.

This soil should be treated with limestone at the rate of 2 to 3 tons an acre and then sweet clover should be seeded in the small grain. There are no experiment field results available for this type upon which to base suggestions for fertilizer treatment. It is advised, however, that a trial be made of the phosphates for wheat, after the nitrogen and organic-matter deficiencies have been taken care of, as above suggested. Yellow-Gray Silt Loam, as it occurs in Woodford county, is a productive soil when good farming methods are practiced.

Yellow Silt Loam (935, 1135)

Yellow Silt Loam occupies 49.58 square miles, or 9.31 percent of the area of the county. The character of the type varies with the changes in topography, in vegetative covering, and in the soil material from which it was formed. The rapidity of erosion is governed by the above factors, and differences in the rate of removal of surface soil determine to a large extent the character of the type. On the steeper unprotected slopes no true A_1 horizon, or surface soil, is present, and gravel may be exposed. The soil is in general grayish yellow in color and at a depth of about 20 inches becomes compact.

Management.—The management of Yellow Silt Loam is governed largely by slope. The long steep slopes should be kept in timber or in permanent pasture, while the slopes less subject to erosion may be put in grain at intervals. Much of this type as found in Woodford county will grow alfalfa without the use of lime. Advantage should be more generally taken of this fact, as it offers the opportunity to grow a profitable crop and at the same time control erosion. For more specific information on the control of erosion, the reader is referred to the discussion of the Vienna experiment field, page 52, and also to Bulletin 207 and Circular 290 of this Station.

Dune Sand (1181)

Dune Sand occurs in small disconnected areas on the upland near Spring Bay. The total area of the type in Woodford county is slightly less than one square mile. The time which has elapsed since the soil material of this type was deposited has been too short to allow the formation of horizons. The surface to a depth of about 7 inches is a grayish yellow, medium-coarse sand, and the only observable difference which appears below this depth is a change in color to brownish yellow.

Management.—Dune Sand, as it occurs in Woodford county, is less coarse than is usual for the type and is fairly well adapted to the general farm crops. It is medium acid and requires about 2 tons of limestone an acre to grow sweet clover or alfalfa. It is well suited to the production of melons or other crops liking a sandy soil. It should grow good potatoes if well fertilized with a mixture high in soluble phosphate and potash. For an account of experiments on sand, see the discussion of the Oquawka experiment field, page 54.

SWAMP AND BOTTOM-LAND SOILS

In the group designated as 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.

Deep Peat (1401)

A total of only 384 acres of Deep Peat is found in Woodford county and most of the areas are untilled because the drainage has not been taken care of. When drained, this type is well adapted to trucking and also grows good corn when fertilized with potash salts. Experiments in improving the fertility of Peat were carried on at the Manito field, described on page 56.

Brown Silt Loam (1426)

Brown Silt Loam, Bottom, occurs in the Illinois bottom north of Partridge creek and adjacent to the swamp found in this corner of Woodford county, from which it is protected by a dike. The A_1 horizon is dark brown silt loam to a depth of about 8 or 9 inches. Below this depth, the color becomes slightly drabbish brown and gradually changes to a drabbish gray with rust-colored iron spots. The texture becomes finer with increasing depth. There are, however, no well-developed horizons because of the youth of this soil.

Management.—Brown Silt Loam, Bottom, is an excellent soil and when properly drained and protected from flooding is very desirable farm land. No treatment is advised for this type in Woodford county other than good farming, the return of fresh organic matter at regular intervals, and the use of lime if experience shows this material to be needed.

Mixed Loam (1454)

Mixed Loam occurs in the Illinois bottom and also in the smaller bottoms which are tributary to Illinois river. A total of 31.76 square miles of the type is found in Woodford county.

This type as it is mapped varies greatly in nearly all the characters which are taken into consideration in separating soils into types. It is in reality not a soil type, but is made up of a number of types which occur in areas too small to be shown on the map. The color of this soil varies from black to light brown and the texture from clay loam to sandy loam.

Management.—Mixed Loam, as it occurs in Woodford county, is a productive soil. Provision for the removal of excess water, both the normal rainfall and flood water, is the chief requirement in its management.

Brown Sandy Loam (1460)

Brown Sandy Loam, Bottom, occurs in two small areas in the Illinois bottom north of Panther creek and has a total area of only 70 acres. It differs from the surrounding silt loam in texture and is slightly higher in elevation. The management requirements of this type are not essentially different from those of Brown Silt Loam, Bottom.

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 over-loaded 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, or terrace. Finer material later deposited on the sand and gravel of the fill constitutes the mineral portion of the soil.

Brown Silt Loam Over Gravel (1527)

Brown Silt Loam Over Gravel occurs, for the most part, in a belt about half a mile wide and four miles long south of Spring Bay. It occupies a total area of 2.22 square miles. The A_1 horizon is brown silt loam which changes gradually to a yellowish brown silt loam, becoming fairly compact at 25 to 30 inches in depth.

This type varies somewhat in agricultural value depending on distance from the bluff. As the bluff is approached, the soil becomes better because of the calcareous outwash material which it receives. Along the edge of the type towards the river, small areas or narrow belts of relatively poor land occur which are drouthy because of the open, sandy subsoil.

Management.—Brown Silt Loam Over Gravel requires in general the same management as Brown Silt Loam, Upland (see page 15), and except for the poorer portions of the type mentioned above should respond satisfactorily.

Brown Silt Loam On Gravel (1526.4)

A total of only 96 acres of Brown Silt Loam On Gravel is mapped in Woodford county. The surface soil of this type is the same as that of the preceding type, Brown Silt Loam Over Gravel. The difference between the two types lies in the fact that the gravel substratum is nearer the surface in the Brown Silt Loam On Gravel, making this type more generally drouthy.

Management.—Brown Silt Loam On Gravel is not a good soil for general farming because of its drouthy nature. Nothing can be done to remedy materially this condition. In addition to the use of good farming methods, early-maturing crops should be chosen in so far as possible.

Brown Sandy Loam Over Gravel (1566)

Only a small amount of Brown Sandy Loam Over Gravel occurs in Woodford county, a total of 128 acres. It is found south of Spring Bay in association with River Sand (1580) and Brown Silt Loam Over Gravel (1527), and was formed by the mixture of sufficient sand from the adjacent dunes with the low-lying silt loam to make a sandy loam. The type varies in texture and in the depth of the sand-silt mixture. The underlying gravel stratum is sufficiently deep not to interfere with moisture movement.

Management.—Brown Sandy Loam Over Gravel is an excellent vegetable or trucking soil and grows good general farm crops. It is medium acid and requires 2 to 3 tons of limestone an acre for alfalfa or sweet clover. The decay of organic matter is rapid in this soil and adequate provision should be made for returning fresh supplies of this essential material to it at regular intervals.

Brown Sandy Loam On Gravel (1560.4)

Brown Sandy Loam On Gravel occurs south of Spring Bay as small areas in association with the sand, sandy loam, and silt loam types of this region. It is similar in appearance to the preceding type, Brown Sandy Loam Over Gravel, and is distinguishable from it only by examining the subsoil. It is a drouthy type because of the nearness of the gravel substratum to the surface. A total of 1,146 acres of this type is found in Woodford county.

Management.—Brown Sandy Loam On Gravel is medium acid and needs 2 or 3 tons of limestone an acre. It is not a good soil for the general farm crops because of its drouthy nature. No method is known of adequately overcoming this defect since this condition is due to the character of the subsoil, which cannot be changed. Some improvement can be made by increasing the organic-matter content of the surface soil, thus slightly increasing its water-holding capacity. The best way to use soil of this drouthy nature is to grow early maturing crops on it, thus largely avoiding the unfavorable effects of dry midsummer weather.

Yellow-Gray Silt Loam Over Gravel (1536)

The largest areas of Yellow-Gray Silt Loam Over Gravel occur along Mackinaw river. A total of 2.87 square miles of the type is found in Woodford county. It is similar to Yellow-Gray Silt Loam, Upland, in all respects except method of formation, and the reader is referred to the discussion of that type (page 18).

Yellow-Gray Sandy Loam Over Gravel (1567)

Yellow-Gray Sandy Loam Over Gravel occurs in narrow belts adjacent to streams where the overflow conditions have been such that sand was carried out by the stream and deposited. Less than half a square mile of this type occurs in Woodford county. It has a yellowish gray sandy loam surface which grades into yellowish sandy loam with a medium degree of compaction. Some gray mottling appears at about 20 inches in depth.

Management.—This type should be managed in the same way as the preceding type, Yellow-Gray Silt Loam Over Gravel. It is a less productive type, because of its high sand content, but will respond satisfactorily to good farming.

River Sand (1580)

A total of 1,088 acres of River Sand occurs south of Spring Bay. This soil material was deposited both by wind and water and has a dune-like topography.

The surface is a brownish yellow sand which passes into yellow sand at a depth of 7 or 8 inches. No B or C horizons have been developed in this soil because of its youth.

Management.—River sand is naturally a poor soil for general farming, but with the use of about 3 tons of limestone an acre will grow good sweet clover and alfalfa, and following a thrifty growth of these legumes, fair crops of corn, wheat, and rye are produced. It is a good melon soil. See page 54 for an account of experiments on the Oquawka field located on Dune Sand, which is very similar to this type as it occurs in Woodford county.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

In order to interpret the soil map intelligently 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 soil type is the unit of classification. Each type has definite characteristics upon which its separation from other types is based. These characteristics are inherent in the strata, or "horizons," which constitute the soil profile in all mature soils. Among them may be mentioned color, structure, texture, and chemical composition. Other items such as native vegetation (whether timber or prairie), topography, and geological origin and formation may assist in the differentiation of types, altho they are not fundamental to it.

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 definitions 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. In describing a matured soil, three horizons designated as A, B, and C are usually considered.

A designates the upper horizon and, as developed under the conditions of a humid, temperate climate, represents the layer of extraction or eluviation; that is to say, material in solution or in suspension has passed out of this zone thru the processes of weathering.

B represents the layer of concentration or illuviation; that is, the layer developed as a result of the accumulation of material thru the downward movement of water from the A horizon.

C designates the layer lying below the B horizon and in which the material has been less affected by the weathering processes.

Frequently differences within these strata or zones are discernible, in which case they are subdivided and described under such designations as A_1, and A_2, B_1 and B_2, etc.

Soil Profile. The soil section as a whole is spoken of as the soil profile.

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, columnar, laminated.

Organic-Matter Content. The organic matter of soil is derived largely from plant tissue and it exists in a more or less advanced stage of decomposition. Organic matter forms 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 differentiating 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 material.

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.

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 type names which are adequately descriptive, because the profile of mature soils is usually made up of three 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 listing of 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,* including 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,* formerly considered as 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,* formed by material derived from the Illinoisan or older glaciations
1400 *Late river-bottom and swamp lands,* formed by material derived from 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

Further information regarding these geological areas is given in connection with the general map mentioned above and published in Bulletin 123 (1908).

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 county 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 6.

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 of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium,* and *iron*. Other elements are absorbed from the soil by growing plants, including manganese, silicon, sodium, aluminum, chlorin, and boron. It is probable that these latter elements are present in plants for the most part, not because they are required, but because they are dissolved in the soil water and the plant has no means of preventing their entrance. There is some evidence, however, which indicates that certain of these elements, notably manganese, silicon, and boron, may be either essential but required in only minute quantities, or very beneficial to plant growth under certain conditions, even tho not essential. Thus, for example, manganese has produced marked increases in crop yields on heavily limed soils. Sodium also has been found capable of partially replacing potassium in case of a shortage of the latter element.

TABLE 5.—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 5 shows the requirements of some of our most common field crops with respect to seven important 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 an element removed from an acre of land by a crop of a given yield can easily be computed.

PLANT-FOOD SUPPLY

Of the elements of plant food, three (carbon, oxygen, and hydrogen) are secured from air and water, and the others from the soil. Nitrogen, one of the 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

TABLE 6.—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 5.
[2]Young second-year growth ready to plow under as green manure.
[3]Wood ashes also contain about 1,000 pounds of lime (calcium carbonate) per ton.

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 more than 35,000 pounds. In like manner the phosphorus content varies from about 320 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 of production, then we must look for some outside source of supply. Table 6 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

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 or entirely 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 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.

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 desirable to make the test for carbonates along with the acidity test. Limestone is calcium carbonate, while dolomite is the combined carbonates 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, owing 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 to neutralize the acidity, 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.[1] 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. The sample when tested, therefore, should be at least as dry as when the soil is in good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. 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.

Amounts to Apply.—Acid soils should be treated with limestone whenever such application is at all practicable. The initial application varies with the degree of acidity and will usually range from 2 to 6 tons an acre. The larger amounts will be needed on strongly acid soils, particularly on land being prepared for alfalfa. When sufficient limestone has been used to establish conditions favorable to the growth of legumes, no further applications are necessary until the acidity again develops to such an extent as to interfere with the best growth of these crops. This will ordinarily be at intervals of several years. In the case of an inadequate supply of magnesium in the soil, the occasional use of magnesian (dolomitic) limestone would serve to correct this deficiency. Otherwise, so far as present knowledge indicates, either form of limestone—high-calcium or magnesian—will be equally effective, depending upon the purity and fineness of the respective stones.

Fineness of Material.—The fineness to which limestone is ground is an important consideration in its use for soil improvement. Experiments indicate that a considerable range in this regard is permissible. Very fine grading insures

[1] Since undenatured alcohol is difficult to obtain, some of the denatured alcohols have been tested for making this solution. Completely denatured alcohol made over U. S. Formulas No. 1 and No. 4_1 have been found satisfactory. Some commercial firms are also offering other preparations which are satisfactory.

ready solubility, and thus promptness in action; but the finer the grinding the greater is the expense involved. A grinding, therefore, that furnishes not too large a proportion of coarser particles along with the finer, similar to that of the by-product material on the market, is to be recommended. Altho the exact proportions of coarse and fine material cannot be prescribed, it may be said that a limestone crushed so that the coarsest fragments will pass thru a screen of 4 to 10 meshes to the inch is satisfactory if the total product is used.

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 these legumes, nitrogen may be added to the soil.

Inasmuch as legumes are worth growing for purposes other than the fixation of 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 nitrogeneous 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. Besides phosphorus, acid phosphate also contains 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, of the element phosphorus. The rock should be ground to a powder, fine enough to pass thru a 100-mesh sieve, or even finer.

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

In considering the conservation of potassium on the farm it should be remembered that in average livestock 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 livestock farming, is negligible on land containing 25,000 pounds or more of potassium in the surface 6⅔ inches.

The Calcium and Magnesium Problem

When measured by crop removals of the plant-food elements, calcium is often more limited in Illinois soils than is potassium, while magnesium may be occasionally. In the case of calcium, however, the deficiency is likely to develop more rapidly and become much more marked because this element is leached out of the soil in drainage water to a far greater extent than is either magnesium or potassium.

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 direct 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 Illinois) 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 under Illinois conditions.

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 necessary, it nevertheless reduces the amount of organic matter, and provision must therefore be made for maintaining the supply. The practical way to do this is to turn under the farm manure, straw, cornstalks, 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 cornstalks 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 cornstalks. 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 cornstalks is one and one-half times that of a ton of manure, and a ton of dry cornstalks 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 cornstalks during the winter and often rather late in the spring after the frost is out of the ground. This trampling 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. As a general principle the shorter rotations, with the frequent introduction of leguminous crops, are the better adapted for building up poor soils.

Following are a few suggested rotations 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 livestock 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 grown four times. Alalfa 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 fields if moved every six years.

Four-Year Rotations

First year —Corn	*First year* —Corn
Second year —Wheat or oats (with clover)	*Second year* —Corn
Third year —Clover	*Third year* —Wheat or oats (with clover)
Fourth year —Wheat (with clover)	*Fourth year* —Clover
First year —Corn	*First year* —Wheat (with clover)
Second year —Cowpeas or soybeans	*Second year* —Clover
Third year —Wheat (with clover)	*Third year* —Corn
Fourth year —Clover	*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	*First year* —Wheat or oats (with clover)
Second year —Oats or wheat (with clover)	*Second year* —Corn
Third year —Clover	*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 Woodford County)

The University of Illinois has operated 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 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 of Fields

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, livestock farming and grain farming.

In the livestock 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 the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was 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 livestock system. Some modifications have been made in recent years.

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 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, usually 200 pounds of kainit. When kainit was not available, owing to conditions brought on by the World war, potassium carbonate was used. 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, in the form of rock phosphate unless otherwise designated (aP = acid phosphate, bP = bonemeal, rP = rock phosphate, sP = slag phosphate)
K = Potassium (usually in the form of kainit)
N = Nitrogen (usually in the form contained in dried blood)
Le = Legume used as green manure
Cv = Cover crop
( ) = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed
| = Heavy vertical rule, indicating the beginning of complete treatment
|| = Double vertical rule, indicating a radical change in the cropping system

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.

THE MT. MORRIS FIELD

The Mt. Morris experiment field was established in 1910 at Mt. Morris in Ogle county. The soil represents fairly well the type Light Brown Silt Loam, altho the plots are not altogether uniform in this respect. The plots considered

TABLE 7.—MT. MORRIS FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields, 1913-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *13 crops*	Oats *13 crops*	Wheat *11 crops*	Clover[1] *10 crops*	Soybeans *2 crops*
1	0	45.2	59.1	22.8	(2.10)	(1.56)
2	M	59.5	67.8	27.7	(2.62)	(1.70)
3	ML	64.2	70.2	33.7	(3.00)	(1.80)
4	MLrP	64.5	71.4	35.5	(2.92)	(1.92)
5	0	44.9	56.5	23.0	(1.74)	13.5
6	R	51.3	60.9	25.3	(1.90)	16.0
7	RL	62.5	69.3	32.1	(2.27)	18.9
8	RLrP	65.7	70.2	35.7	(2.22)	20.7
9	RLrPK	67.4	70.5	35.5	(2.20)	20.0
10	0	44.0	53.6	24.7	(1.95)	(1.68)
	M over 0	14.3	8.7	4.9	(.52)	(.14)
	R over 0	6.4	4.4	2.3	(.16)	2.5
	ML over M	4.7	2.4	6.0	(.38)	(.10)
	RL over R	11.2	8.4	6.8	(.37)	2.9
	MLrP over ML	.3	1.2	1.8	−(.08)	(.12)
	RLrP over RL	3.2	.9	3.6	−(.05)	1.8
	RLrPK over RLrP	1.7	.3	−.2	−(.02)	− .7

[1]Some clover seed evaluated as hay.

here comprize four series under a rotation of corn, oats, clover, and wheat, with soil treatments as indicated in the accompanying table. The application of straw to the residues plots has been discontinued in these later years. In 1922 the application of limestone and in 1923 the application of rock phosphate were indefinitely suspended in order to observe the residual effect of these materials.

A summary of the results of the work is given in Table 7, in the form of the average annual crop yields for the years since the complete soil treatments have been in effect.

The results bring out clearly the need of this soil for organic matter. Without limestone, manure has been far more effective than residues. Limestone, however, has been applied with beneficial effect either with manure or with residues, but the response has been decidedly the greater in the residues system.

Rock phosphate has produced no significant effect when applied with manure and limestone, and the increases in yield obtained from rock phosphate in the residues system have not been sufficient to cover the cost of material as it has been used. Potassium as used in these experiments has produced no significant effect on crop yields.

THE KEWANEE FIELD

A field on soil similar to much of the Brown Silt Loam as it occurs in Woodford county is the Kewanee field, located in Henry county about three miles southwest of Kewanee. This field has been under way since 1915. The crops grown are wheat, corn, oats, and clover. The arrangement of plots and the treatments applied are indicated in Table 8.

TABLE 8.—KEWANEE FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1917-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *9 crops*	Oats *9 crops*	Wheat *7 crops*	Clover *8 crops*
1	0	54.4	58.4	29.9	(1.85)
2	M	64.3	69.0	31.5	(2.36)
3	ML	68.2	71.8	34.0	(2.32)
4	MLrP	69.1	70.1	38.3	(2.45)
5	0	55.5	59.8	30.5	(1.74)
6	R	57.5	58.6	31.5	(1.71)
7	RL	66.0	63.0	32.5	(1.93)
8	RLrP	70.3	66.9	37.8	(2.08)
9	RLrPK	72.4	68.2	37.8	(2.12)
10	0	51.2	54.6	30.1	(1.73)
	M over 0	9.9	10.6	1.6	(.51)
	R over 0	2.0	−1.2	1.0	−(.03)
	ML over M	3.9	2.8	2.5	−(.04)
	RL over R	8.5	4.4	1.0	(.22)
	MLrP over ML	.9	−1.7	4.3	(.13)
	RLrP over RL	4.3	3.9	5.3	(.15)
	RLrPK over RLrP	2.1	1.3	0.0	(.04)

Summarizing the data as shown in Table 8 the following observations may be made.

1. The response to treatment with stable manure stands out clearly in the increase in production.

2. Residues without limestone have not produced a very decided effect on crop yields.

3. The effect of limestone appears to have been beneficial used either with manure or with residues.

4. Phosphorus, as usual, has been more effective applied with residues than with manure. In the residues system the rock phosphate has just about returned the cost of application, but in the manure system the increases in crop yield have fallen far short of covering the cost.

5. Potassium has produced no effect upon the yields of these crops that can be considered significant.

THE BLOOMINGTON FIELD

The experiments on the Bloomington field are of interest in connection with the management of much of the upland prairie soil as it occurs in Woodford county. This field is located in McLean county, northeast of the city of Bloomington. The work was started in 1902. A radical change in the plan of the experiments was made in 1923, and for this reason the present discussion will involve results only up to that year. Altho a fairly long period of years is covered in these experiments, the field has only a single series of plots, so that only one kind of crop is represented each season. The crops employed have been corn,

corn, oats, clover, and wheat; and, since 1905, they have been grown in the sequence named.

On account of irregularities in the land results from Plots 1 and 10 are not considered altogether reliable. They, therefore, are not included in the figures presented. Since these are the only unlimed plots, no conclusion can be drawn regarding the action of limestone on this field.

Commercial nitrogen applied in the form of dried blood was used in the early years up to 1905, when crop residues and clover were substituted. The phosphorus on this field was applied in the form of steamed bone meal and at the rate of 200 pounds an acre a year.

Table 9 presents a summary of the work by annual average crop yields. The comparisons in the lower part of the table show the effect of the different plant-food materials in the various combinations in which they were applied. As might be expected, the residues treatment, supplying organic matter and nitrogen, shows a beneficial effect. It is of interest to note that the effect of the residues is greater on the phosphorus plots than on those not receiving phosphorus.

The outstanding feature of the results on the Bloomington field is the effect of phosphorus applied in the form of steamed bone meal. In every crop on every plot where bone meal was applied there has been a remarkable response to the treatment as shown by the increases in yields. This response appears in all the combinations, even without the presence of residues, altho in combination with

TABLE 9.—BLOOMINGTON FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1902-1923—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *10 crops*	Oats *4 crops*	Wheat *4 crops*	Clover[1] *3 crops*
2	L	41.5	44.7	24.1	(.80)
3	LR	47.5	46.2	27.9	(.88)
4	LbP	55.8	54.3	45.7	(2.54)
5	LK	46.2	43.5	25.5	(.93)
6	LRbP	60.6	66.0	49.7	(1.19)
7	LRK	48.6	46.8	27.5	(.82)
8	LbPK	60.9	57.2	44.5	(2.44)
9	LRbPK	64.2	63.1	50.4	(.81)
	Increases: Bushels per acre				
	For Residues				
	LR over L	6.0	1.5	3.8	(.08)
	LRbP " LbP	4.8	11.7	4.0	−(1.35)
	LRK " LK	2.4	3.3	2.0	−(.11)
	LRbPK " LbPK	3.3	5.9	5.9	−(1.63)
	For Phosphorus				
	LbP over L	14.3	9.6	21.6	(1.74)
	LRbP " LR	13.1	19.8	21.8	(.31)
	LbPK " LK	14.7	13.7	19.0	(1.51)
	LRbPK " LRK	15.6	16.3	22.9	−(.01)
	For Potassium				
	LK over L	4.7	−1.2	1.4	(.13)
	LRK " LR	1.1	.6	−.4	−(.06)
	LbPK " LbP	5.1	2.9	−1.2	−(.10)
	LRbPK " LRbP	3.6	−2.9	.7	−(.38)

[1]Two crops of clover seed on Plots 3, 6, 7, 9, and 10 evaluated as hay.

either residues or potassium the effect is accentuated. For example, if we compare Plot 3 with Plot 6 (limestone and residues with limestone, residues, and phosphorus) we find that the phosphorus treatment has produced an average increase of about 13 bushels of corn to the acre, while the yield of oats has been increased by about 20 bushels, wheat by about 22 bushels, and clover hay by about ⅓ ton. Similar increases appear in comparing Plot 5 with Plot 8, where potassium instead of residues is present.

Thus it appears that on this field, under this system of farming, the lack of phosphorus is distinctly a limiting factor in production, and the application of this element in the form of steamed bone meal is attended by a high financial profit. It is of extreme interest to know whether a similar response would follow the use of other phosphorus carriers, such as rock phosphate and acid phosphate, and experiments are now under way designed to answer this question.

Quite different are the results from the use of potassium on this field. The potassium was applied mainly in the form of potassium sulfate, but in 1917 when this material became unavailable thru war conditions, potassium carbonate was substituted. There has been a moderate increase in the corn yield where potassium was used and particularly where residues were absent. Otherwise, the small gains shown on some plots are offset by losses on other plots, but these small differences are probably well within the limits of experimental error.

THE JOLIET FIELD

The Joliet experiment field is located in Will county about three miles northwest of Joliet. Aside from a few spots of Black Clay Loam On Drab Clay the soil is made up of the types Brown Silt Loam On Calcareous Drift and Brown Silt Loam On Plastic Calcareous Drift. The main plot system, the one which will be considered here, is made up of six series of plots under the soil treatments indicated in Table 10. The original crop rotation practiced included corn, oats, clover, wheat, and soybeans, with alfalfa on a sixth series remaining six years. In 1921 the rotation was changed to corn, corn, oats, clover, and wheat, with a seeding of sweet clover on the residues plots, and alfalfa on the sixth series for six years. Since 1921 all clover has been removed as hay. In 1921 the return of the oats straw was discontinued, as was also the wheat straw the following year. The application of limestone was likewise discontinued in 1922, to be resumed when need for more lime becomes apparent.

The results secured from these experiments are summarized in Table 10 to show the average annual yields of the several crops including the years since the complete soil treatments have been in effect.

In looking over these results one may observe first a beneficial effect of manure on all crops, but most pronounced on the corn. This suggests the importance of carefully conserving and regularly applying all available stable manure. Residues, used alone, have produced some increase in the corn, but have had little effect on the yield of other crops.

Where limestone is applied usually there has been some increase in yield. Limestone has been especially beneficial to alfalfa.

TABLE 10.—JOLIET FIELD, SERIES 100-600: SUMMARY OF CROP YIELDS
Average Annual Yields 1915-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn 16 crops	Oats 11 crops	Wheat 8 crops	Clover[1] 6 crops	Soybeans 4 crops	Alfalfa 4 crops
1	0	31.3	56.4	21.7	(.98)	(1.26)	(1.27)
2	M	40.2	61.8	26.2	(1.31)	(1.39)	(1.69)
3	ML	44.8	63.2	30.4	(1.37)	(1.48)	(2.42)
4	MLrP	48.2	67.4	37.9	(1.66)	(1.59)	(3.21)
5	0	32.3	57.1	21.7	(.95)	12.1	(1.19)
6	R	37.3	58.0	23.3	(.81)	12.1	(1.14)
7	RL	41.1	60.4	25.2	(1.01)	14.1	(1.81)
8	RLrP	46.4	66.2	36.4	(1.55)	16.2	(3.52)
9	RLrPK	50.8	67.0	39.9	(1.67)	16.8	(3.46)
10	0	33.6	57.3	23.0	(1.12)	(1.14)	(1.35)
	M over 0	8.9	5.4	4.5	(.33)	(.13)	(.42)
	R over 0	5.0	.9	1.6	−(.14)	0.0	−(.05)
	ML over M	4.6	1.4	4.2	(.06)	(.09)	(.73)
	RL over R	3.8	2.4	1.9	(.20)	2.0	(.67)
	MLrP over ML	3.4	4.2	7.5	(.29)	(.11)	(.79)
	RLrP over RL	5.3	5.8	11.2	(.54)	2.1	(1.71)
	RLrPK over RLrP	4.4	.8	3.5	(.12)	.6	−(.06)

[1]One crop of seed on Plots 6, 7, 8, and 9 evaluated as hay.

Very marked increases have followed the application of rock phosphate, the use of this material having proved exceedingly profitable on this field. Profitable response to potassium in the fertilizer combination here used has been secured only in the corn and wheat, so that considering the rotation as a whole, the value of crop increase has not been sufficient to cover the cost of material. It is possible that by reducing the expense thru the use of smaller quantities of material, the potassium fertilization could be made profitable.

THE MINONK FIELD

A University soil experiment field is located in Woodford county about a mile west of Minonk. This field was established in 1910. It comprizes 15 acres of dark-colored prairie soil of loessial and drift origin. The experimental plots lie mainly on Black Clay Loam On Drab Clay, altho a detailed examination reveals the presence of three other soil types distinguishable on account of certain profile characteristics. These are Brown Silt Loam, Brown Silt Loam On Calcareous Drift, and Brown Silt Loam On Calcareous Clay. The distribution of these soil types, as well as the arrangement of plots, is charted on the accompanying diagram (Fig. 2). The diagram also indicates by contour lines the topography of the land.

The field is laid out into four series of 10 plots each. The plots are one-fifth acre in size except in Series 100, where they are one-tenth acre. A crop rotation of corn, oats, clover, and wheat was practiced until 1923, when it was changed to corn, corn, oats, and wheat, with a seeding of hubam clover in the oats on all plots and biennial sweet clover in the wheat on the residues plots. In 1921 the practice of returning the oats straw on the residues plots was discontinued, and

TABLE 11.—MINONK FIELD: ANNUAL CROP YIELDS

Bushels or (tons) per acre

Plot No.	Soil treatment applied	1910 Barley[1]	1911 Corn[2]	1912 Oats[4]	1913 Clover[4]	1914 Wheat[5]	1915 Corn	1916 Oats	1917 Soybeans	1918 Wheat	1919 Corn	1920 Oats	1921 Soybeans	1922 Wheat	1923 Corn	1924 Oats	1924 Stubble clover	1925 Wheat	1926 Corn	
101	0.........	38.1	72.8	42.8	(3.94)	53.2	51.8	63.1	(1.43)	40.1	55.8	71.2	34.8	34.3	38.4	58.8	(.92)	29.2	55.4	
102	M........	29.4	66.8	43.4	(4.04)	51.3	56.4	55.3	(1.70)	45.0	65.6	73.4	35.8	35.8	49.8	65.3	(1.21)	28.3	72.0	
103	ML.......	29.5	63.1	39.7	(3.86)	55.8	61.4	55.6	(1.94)	38.7	67.2	67.5	37.2	31.8	50.2	61.6	(.85)	29.8	67.4	
104	MLrP....	33.7	61.0	39.1	(3.61)	49.0	57.0	50.9	(2.06)	34.2	66.8	63.4	36.5	30.2	47.6	54.1	(.89)	28.3	69.0	
105	0.........	33.0	58.6	41.3	.67	53.0	50.0	52.2	20.0	38.3	58.6	65.0	34.5	30.0	37.4	48.1	(.95)	29.2	53.0	
106	R.........	36.9	72.3	51.3	.83	47.0	52.2	55.9	19.2	34.8	54.2	96.6	33.8	32.5	55.2	85.9	(.80)	37.7	71.6	
107	RL.......	39.9	71.2	42.5	.67	35.2	43.8	58.1	18.0	28.2	60.2	92.5	32.3	31.0	52.0	85.3	(.83)	30.2	68.2	
108	RLrP.....	44.0	72.4	37.5	.67	33.8	40.2	60.6	17.8	32.0	59.2	94.4	31.5	33.3	51.4	84.7	(1.06)	30.0	78.0	
109	RLrPK...	39.5	73.8	31.9	.50	29.8	43.8	60.6	16.0	31.0	55.6	89.4	25.8	30.3	51.8	83.8	(1.17)	25.5	69.6	
110	0.........	42.4	68.8	34.4	(1.63)	27.3	43.6	56.9	(1.23)	22.7	51.4	71.2	25.5	21.2	30.2	54.1	(.57)	16.2	49.6	
		Soybeans[1]	Wheat[3]	Corn	Oats	Soybeans	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Corn	Corn		Oats	Wheat	Stubble Clover
201	0.........	13.3	25.9	65.4	39.7	(1.10)	52.2	37.5	76.1	(4.35)	33.3	56.4	31.6	(3.36)	48.9	49.3		65.3	36.6	....
202	M........	14.7	25.7	70.6	38.0	(1.22)	52.6	35.7	67.0	(4.30)	33.7	67.0	33.3	(4.03)	56.5	46.9		68.6	38.2	....
203	ML.......	15.0	28.5	69.4	41.6	(1.23)	53.6	35.1	73.8	(4.57)	32.8	68.1	32.3	(3.59)	59.2	46.6		66.1	37.0	....
204	MLrP.....	14.7	25.8	74.3	41.6	(.98)	61.1	31.6	65.8	(4.59)	32.4	61.7	32.3	(3.42)	54.9	46.0		65.6	38.8	....
205	0.........	13.3	26.0	63.9	39.1	8.7	51.0	26.4	63.6	.75	31.2	54.8	31.7	(2.94)	46.5	47.8		66.6	35.6	....
206	R.........	12.5	26.8	65.0	35.0	10.8	51.2	37.1	78.9	1.08	32.7	62.0	30.6	(3.16)	54.2	56.1		71.6	37.6	(1.22)
207	RL.......	13.5	22.7	69.7	36.2	8.5	49.9	34.9	75.0	.92	33.0	61.6	26.4	(2.75)	48.3	54.9		68.6	31.1	(1.20)
208	RLrP.....	11.2	22.2	68.4	40.2	8.8	47.6	35.6	79.7	.42	36.2	65.8	29.4	(3.18)	49.1	56.4		66.4	37.1	(1.36)
209	RLrPK...	11.8	23.8	69.8	44.4	7.7	48.1	34.6	78.9	.67	34.2	64.2	30.3	(3.38)	49.2	58.1		70.3	34.7	(1.59)
210	0.........	12.7	20.0	66.3	44.1	8.5	44.5	22.8	63.8	(3.75)	32.4	44.7	33.9	(2.35)	35.0	41.1		57.3	26.8	....

[1]No treatment. [2]Residues only. [3]No manure or limestone. [4]Residues and limestone only. [5]No manure.

TABLE 11.—*Concluded*

Bushels or (tons) per acre

Plot No.	Soil treatment applied	1910 Oats[1]	1911 Clover[2]	1912 Wheat[4]	1913 Corn	1914 Oats	1915 Soybeans	1916 Wheat	1917 Corn	1918 Oats	1919 Clover	1920 Wheat	1921 Corn	1922 Oats	1923 Wheat	1924 Corn	1925 Corn	1926 Oats	1926 Stubble Clover
301	0........	67.2	(2.75)	11.1	54.1	40.6	(1.72)	30.7	54.7	60.3	(2.41)	42.8	56.4	74.8	31.3	45.8	60.1	52.8	(.53)
302	M........	66.9	(2.65)	11.3	63.9	42.0	(1.70)	37.7	63.8	65.3	(2.72)	47.5	75.8	81.4	37.9	68.8	70.5	66.6	(.67)
303	ML.......	65.5	(2.54)	15.6	60.6	43.3	(1.78)	35.1	67.5	65.3	(2.48)	42.4	83.3	80.9	28.8	60.5	73.5	61.4	(.82)
304	MLrP.....	62.8	(2.65)	17.9	65.2	44.8	(1.70)	38.0	69.3	64.7	(2.67)	46.0	85.4	76.9	37.3	56.2	77.3	63.3	(.85)
305	0........	58.3	(2.82)	15.3	57.9	45.0	19.7	34.5	46.4	58.6	(1.75) .59	42.8	70.4	66.1	30.8	40.6	49.1	55.5	(.77)
306	R........	58.3	....(3)..	17.8	64.0	44.5	18.6	38.3	60.6	60.9	(1.54) .54	40.2	77.6	69.7	36.8	53.3	63.7	48.4	(1.02)
307	RL.......	56.7	....(3)..	15.8	62.0	45.8	18.3	35.5	70.0	60.9	(1.38) .56	35.8	81.7	67.0	30.4	60.5	61.4	47.8	(.97)
308	RLrP.....	56.9	....(3)..	18.0	58.7	42.5	20.7	34.4	68.7	63.1	(1.21) .39	39.0	77.5	70.5	29.9	67.2	66.2	52.5	(1.06)
309	RLrPK...	61.9	....(3)..	13.3	59.2	38.8	19.2	31.8	69.9	64.5	(1.13) .30	35.6	80.3	69.2	30.9	56.2	61.6	53.4	(1.24)
310	0........	64.2	(2.05)	6.7	44.5	29.2	(1.63)	28.2	52.9	59.5	(1.81)	33.5	61.2	63.3	23.6	38.4	31.8	46.3	(.59)
		Corn[1]	Oats[2]	Soybeans[5]	Wheat[4]	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats	Wheat	Corn	Corn	
401	0........	52.0	52.5	(1.27)	33.8	19.9	89.4	(2.07)	9.9	60.9	52.0	(.70)	29.2	52.0	49.7	26.8	42.2	45.3	
402	M........	48.9	52.5	(1.54)	31.8	22.6	93.0	(2.06)	14.0	70.5	49.2	(.92)	28.5	70.3	57.7	33.9	68.7	63.5	
403	ML.......	50.9	55.3	(1.10)	27.9	18.7	93.4	(1.82)	11.2	75.6	49.5	(1.24)	29.3	71.3	57.2	39.6	68.8	58.1	
404	MLrP.....	51.8	49.4	(1.24)	33.5	24.7	103.1	(2.32)	17.1	78.5	49.5	(1.66)	30.1	73.0	64.2	39.9	74.4	59.1	
405	0........	52.4	55.6	10.7	33.7	24.2	93.4	.25	17.9	61.4	48.6	(.54)	28.2	54.8	50.5	33.8	43.9	44.8	
406	R........	49.6	56.4	10.6	39.2	33.8	88.1	.08	23.9	71.4	48.8	(1.11)	29.4	74.1	55.2	35.0	58.9	55.7	
407	RL.......	45.4	54.8	11.5	38.7	38.6	100.0	0.00	21.2	77.3	48.0	(1.93)	26.4	83.2	58.9	38.3	74.4	64.2	
408	RLrP.....	45.0	55.5	11.5	41.2	35.8	101.9	.08	22.8	78.3	49.4	(2.09)	28.8	87.3	64.5	41.1	71.0	69.0	
409	RLrPK...	51.6	53.3	11.4	44.0	35.9	105.5	.08	21.5	70.0	49.2	(1.89)	32.7	78.7	65.0	41.2	70.9	57.5	
410	0........	45.4	53.4	13.0	36.7	27.5	106.0	(2.30)	12.1	58.0	45.2	(1.28)	30.7	55.2	61.3	32.0	43.2	52.6	

[1]No treatment. [2]Residues only. [3]Growth plowed down. [4]No manure. [5]Residues and limestone only.

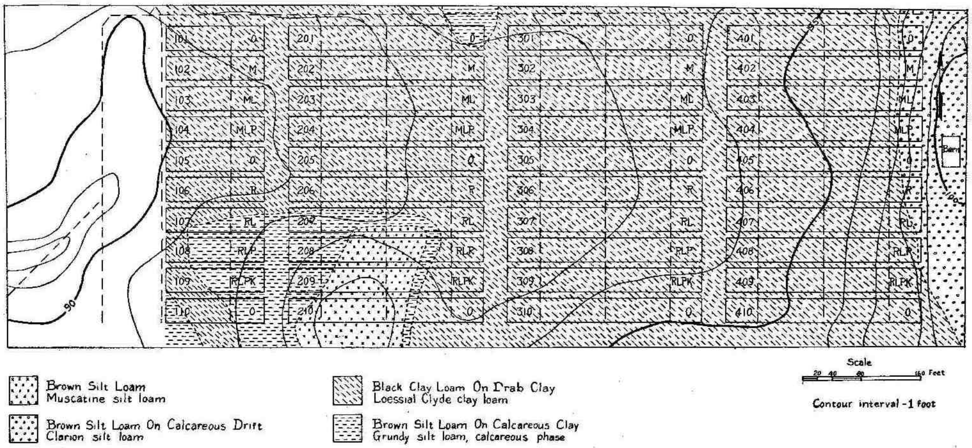

FIG. 2.—DIAGRAM OF THE MINONK EXPERIMENT FIELD

This diagram shows the arrangement of plots, the soil treatments applied, the location of the different soil types, and by means of contour lines, the natural drainage of this field.

in 1922 the return of the wheat straw was likewise discontinued. Up to this time limestone, varying in total quantity from 7½ to 9 tons an acre on the different series, had been applied. These applications were then suspended until such time as the need for more lime becomes apparent. The applications of phosphate were likewise indefinitely suspended in 1923 after evening up the total phosphate applied to 4 tons an acre on all the phosphate plots.

TABLE 12.—MINONK FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1912-1926—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *19 crops*	Oats *14 crops*	Wheat *12 crops*	Clover[1] *7 crops*	Soybeans *4 crops*
1	0	50.0	59.0	33.0	2.05	19.3
2	M	61.0	61.2	36.1	2.27	20.5
3	ML	61.2	60.7	34.2	2.20	21.7
4	MLrP	61.7	60.0	36.1	2.34	21.0
5	0	49.0	56.0	33.6	1.22	20.7
6	R	59.0	62.2	35.8	1.33	20.6
7	RL	61.4	62.2	32.6	1.33	19.3
8	RLrP	62.3	64.3	34.4	1.36	19.7
9	RLrPK	59.8	64.5	33.1	1.41	17.2
10	0	45.3	56.6	27.0	1.81	15.3
	M over 0	11.0	2.2	3.1	.22	1.2
	R over 0	10.0	6.2	2.2	.11	− .1
	ML over M	.2	− .5	−1.9	− .07	1.2
	RL over R	2.4	0.0	−3.2	0.00	−1.3
	MLrP over ML	.5	− .7	1.9	.14	− .7
	RLrP over RL	.9	2.1	1.8	.03	.4
	RLrPK over RLrP	−2.5	.2	−1.3	.05	−2.5

[1]Including the 1919 seed crop from Plots 105, 106, 107, 108 and 109 evaluated as hay and also two crops of stubble clover.

A record of the yield of all crops produced in these experiments is given in Table 11, but for convenience the results obtained since the complete soil treatments have been in effect are summarized in Table 12.

In looking over these results, one observes first the naturally high productiveness of this land. There is more or less response to farm manure; in the corn the yield is markedly increased by its use. Residues alone have likewise increased the yields of the grain crops. Limestone seems to have had no material effect on crop yields. Evidently this soil does not need lime. Rock Phosphate has proved ineffective when applied with manure and limestone, and when used with residues and limestone the increases in yield are too small to offset the cost of material. Potassium as used in these experiments has likewise been ineffective.

These results therefore indicate the advisability of furnishing plenty of organic matter, either thru stable manure or thru crop residues, including leguminous green manure, as the best practical means of improving the productiveness of this naturally fertile soil.

THE HARTSBURG FIELD

The results of experiments on the Hartsburg field are introduced as representing the soil type Black Clay Loam On Drab Clay. This field is located in Logan county just east of Hartsburg. The work began in 1911. The field was laid off into five series of 10 plots each. The crop rotation up to 1923 was wheat, corn, oats, and clover, with alfalfa growing on a fifth series. The soil treatments

TABLE 13.—HARTSBURG FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1913-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn[1] 17 crops	Oats 13 crops	Wheat 11 crops	Clover[2] 6 crops	Soybeans 2 crops	Alfalfa[3] 10 crops
1	0	46.7	47.6	25.6	(2.19)	(1.29)	(3.47)
2	M	56.6	53.0	30.1	(2.59)	(1.65)	(3.67)
3	ML	62.9	58.7	35.6	(2.67)	(1.82)	(3.91)
4	MLrP	61.5	58.6	38.1	(2.80)	(1.93)	(4.19)
5	0	52.6	46.2	30.9	(1.48)	25.8	(3.33)
6	R	62.6	54.9	34.1	(1.91)	26.8	(3.78)
7	RL	66.9	53.0	31.3	(1.82)	28.5	(3.45)
8	RLrP	65.8	57.4	35.3	(1.97)	26.2	(4.04)
9	RLrPK	65.2	56.7	34.7	(1.89)	26.5	(4.16)
10	0	52.7	48.3	31.6	(2.35)	(1.69)	(3.20)
	M over 0	9.9	5.4	4.5	(.40)	(.36)	(.20)
	R over 0	10.0	8.7	3.2	(.43)	1.0	(.45)
	ML over M	6.3	5.7	5.5	(.08)	(.17)	(.24)
	RL over R	4.3	−1.9	−2.8	−(.09)	1.7	−(.33)
	MLrP over ML	−1.4	− .1	2.5	(.13)	(.11)	(.28)
	RLrP over RL	−1.1	4.4	4.0	(.15)	−2.3	(.59)
	RLrPK over RLrP	− .6	− .7	− .6	−(.08)	.3	(.12)

[1]One corn crop without residues.
[2]One crop stubble clover included; some seed evaluated as hay on Plots 5, 6, 7, 8, and 9.
[3]No residues for the first 6 crops.

are as indicated in Table 13. The table summarizes, by crops, the yields of grain for the period during which the plots have been under full treatment.

The outstanding feature of these results is the large increase in yields produced by residues, which even exceeds the increase brought about by the use of stable manure.

The behavior of limestone on this field is rather peculiar in that it has been more beneficial where applied with manure than where used with residues. Used with manure, limestone shows some increase in all crops, while with residues, the effect on several of the crops appears negative.

Altho rock phosphate has given some increases in wheat yield in both manure and residues systems, the results with other crops have been such as to render the use of this material unprofitable on this field.

The addition of potassium appears to have produced no significant effect upon the yields of any of the crops.

It may be mentioned that new experiments have been recently started on these plots which are designed to answer some of the questions brought out by the foregoing results. For example, the effect of applying phosphorus in other carriers and in different combinations, as well as testing the residual effect of phosphate already applied, is being tried.

THE VIENNA FIELD

Inasmuch as about 50 square miles in Woodford county is made up of Yellow Silt Loam, much of which is subject to erosion, it is believed that an account of some experiments on the Vienna field will be of interest here.

In 1906 the University acquired a 16-acre tract of badly eroded land characteristic of the region near Vienna in Johnson county. The whole area with the exception of about three acres had been abandoned because so much of the surface soil had washed away and there were so many gullies as to render further cultivation of this land unprofitable. Experiments were started at once to reclaim this land, the different methods described below being used for this purpose.

The field was divided into five sections. The sections designated as A, B, and C were divided into four plots each, and D into three plots. On section A, which included the steepest part of the area and contained many gullies, the land was built up into terraces at vertical intervals of 5 feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without much washing.

On Section B the so-called embankment method was used. By this method erosion is prevented by plowing up ridges sufficiently high so that on the occasion of a heavy rainfall, if the water breaks over, it will run over in a broad sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two excep-

FIG. 3.—VIEW OF AN UNIMPROVED HILLSIDE JUST OVER THE FENCE FROM THE FIELD SHOWN IN FIG. 4

tions, about 8 loads of manure per acre were turned under each year for the corn crop.

The land on section D was washed to about the same extent as that of section C. As a check on the different methods of reducing erosion, the land on section D was farmed in the most convenient way, without any special effort being made to prevent washing.

Section E was badly eroded and gullied and no attempt was made to crop it other than to fill in the gullies with brush and to seed the land to grass.

Sections A, B, C, and D was not entirely uniform; some parts were washed more than others and portions of the lower-lying land had been affected by soil

FIG. 4.—CORN GROWING ON IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD. THIS LAND FORMERLY HAD BEEN BADLY ERODED. COMPARE WITH FIG. 3

material washed down from above. When the field was secured, the higher land had a very low producing capacity. On many spots little or nothing would grow.

Limestone was applied to the entire field at the rate of 2 tons an acre. Corn, cowpeas, wheat, and clover were grown in a four-year rotation on each section except D, which had but three plots.

The results shown in Table 14 indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn

TABLE 14.—VIENNA FIELD: HANDLING HILLSIDE LAND TO PREVENT EROSION
Average Annual Yields 1907-1915—Bushels or (tons) per acre

Section	Method	Corn *7 crops*	Wheat *7 crops*	Clover *3 crops*
A	Terrace	31.4	9.0	(.68)
B	Embankments and hillside ditches	32.4	12.7	(.97)
C	Organic matter, deep contour plowing, and contour planting	27.9	11.7	(.80)
D	Check	14.1	4.6	(.21)

from the protected series (A, B, and C) was 30.6 bushels an acre, as against 14.1 bushels for series D; wheat yielded 11.1 bushels in comparison with 4.6 bushels; and clover .82 ton in comparison with .21 ton.

A comparison of Figs. 3 and 4 will serve to indicate the possibility of improving this type of soil.

THE OQUAWKA FIELD

In 1913 the University established an experiment field on Dune Sand, Terrace, in Henderson county, near the Mississippi river. 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. Table 15 indicates the kinds of treatment applied, the amounts of the materials used being in accord with the standard practice, as explained on page 42.

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 2.9 bushels of corn from the use of potassium salts, with ordinary prices this would not be a profitable treatment.

The slight increases or decreases appearing in the other crops probably lie within the experimental error.

A significant fact which the general summary does not bring out is that the improvement under favorable treatment has been progressive, as evidenced by a very marked upward trend in production after the first few years. For example, we note that the yield of corn under the limestone-residues treatment has been 36.7 bushels an acre as an average for the 11 crops since full treatment started, but if we take an average of the last five crops the yield rises to 45.7 bushels. Likewise the average yield of wheat under this same treatment is 13.9 bushels for the eleven-year period, but the average for the last five years is 19.6 bushels.

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 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.

Manure
Yield: nothing

Manure and limestone
Yield: 4.43 tons an acre

FIG. 5.—ALFALFA ON THE OQUAWKA FIELD

These pictures show the possibility of improving this unproductive sandy land of the Oquawka field. Both plots were seeded alike to alfalfa. Where manure alone was applied, the crop was a total failure, but where limestone in addition to manure was applied, nearly 4½ tons of alfalfa hay was obtained as the season's yield.

TABLE 15.—OQUAWKA FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1915-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn 11crops	Soy-beans[1] 11crops	Wheat 11 crops	Sweet Clover[2] 7 crops	Rye 9 crops	Alfalfa 8 crops
1	0	19.8	(1.01)	7.7	0.00	11.9	(.35)
2	M	25.0	(1.20)	10.9	0.00	13.3	(.56)
3	ML	32.2	(1.60)	14.6	1.14	24.5	(2.05)
4	MLrP	31.9	(1.58)	15.0	1.14	23.0	(2.12)
5	0	20.1	(.78)	9.8	0.00	11.7	(.08)
6	R	21.8	(.76)	11.1	0.00	12.7	(.09)
7	RL	36.7	(1.25)	13.9	1.57	24.3	(1.82)
8	RLrP	36.1	(1.25)	14.1	1.43	24.3	(1.79)
9	RLrPK	39.0	(1.17)	13.3	1.67	26.5	(1.87)
10	0	19.1	(.72)	8.8	0.00	10.7	(.02)
	M over 0	5.2	(.19)	3.2	0.00	1.4	(.21)
	R over 0	1.7	−(.02)	1.3	0.00	1.0	−(.01)
	ML over M	7.2	(.40)	3.7	1.14	11.2	(1.49)
	RL over R	14.9	(.49)	2.8	1.57	11.6	(1.73)
	MLrP over ML	−.3	−(.02)	.4	0.00	−1.5	(.07)
	RLrP over RL	−.6	0.00	.2	−.14	0.0	−(.03)
	RLrPK over RLrP	2.9	−(.08)	−.8	.24	2.2	(.08)

[1]Eleven regular crops, together with the extra crop described in footnote 2, averaged as 11 crops. Several crops which were harvested as seed are evaluated in this summary as hay.
[2]Some hay evaluated as seed. In 1918, the sweet clover was killed by early cutting for a hay crop. Soybeans were seeded in July and the ensuing crop is included in the soybean averages.

THE MANITO FIELD

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 16.

There were 10 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. However, 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 an 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) appear to be insufficient.

TABLE 16.—MANITO FIELD: ANNUAL CROP 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 lbs	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.

List of Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
13 Kankakee, 1916
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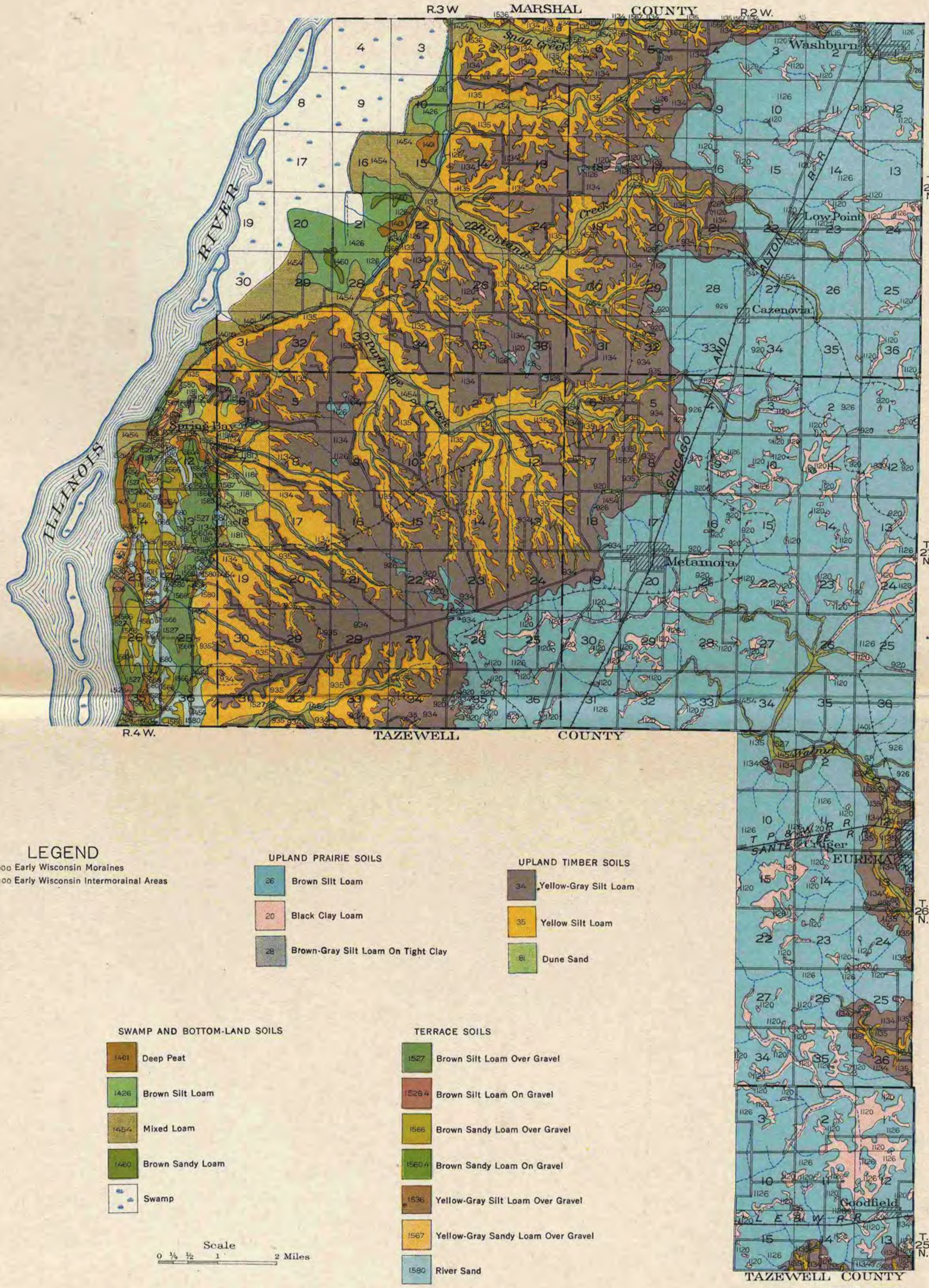
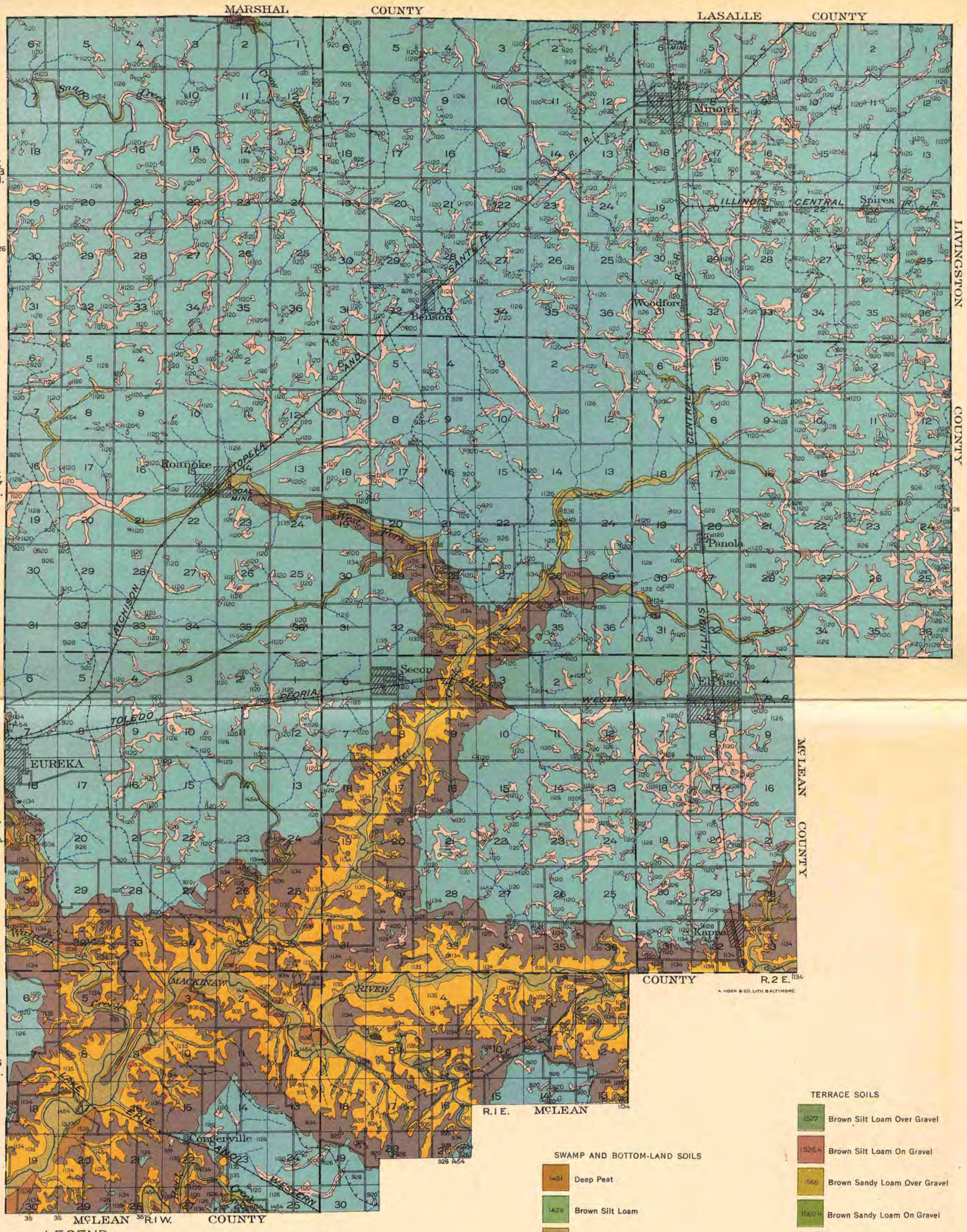


SOIL SURVEY MAP OF WOODFORD COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION



LEGEND

900 Early Wisconsin Moraines
1100 Early Wisconsin Intermorainal Areas

UPLAND PRAIRIE SOILS

26	Brown Silt Loam
20	Black Clay Loam
28	Brown-Gray Silt Loam On Tight Clay

UPLAND TIMBER SOILS

34	Yellow-Gray Silt Loam
35	Yellow Silt Loam
81	Dune Sand

SWAMP AND BOTTOM-LAND SOILS

1401	Deep Peat
1426	Brown Silt Loam
1454	Mixed Loam
1460	Brown Sandy Loam
	Swamp

TERRACE SOILS

1527	Brown Silt Loam Over Gravel
1526.4	Brown Silt Loam On Gravel
1566	Brown Sandy Loam Over Gravel
1560.4	Brown Sandy Loam On Gravel
1536	Yellow-Gray Silt Loam Over Gravel
1567	Yellow-Gray Sandy Loam Over Gravel
1580	River Sand

Scale 0 ¼ ½ 1 2 Miles

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