SALINE COUNTY SOILS

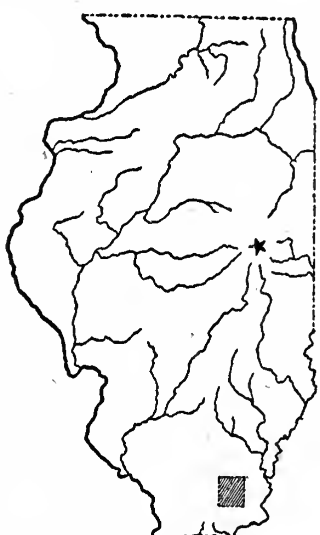
UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

SOIL REPORT No. 33

SALINE COUNTY SOILS

By R. S. SMITH, E. A. NORTON, E. E. DeTURK, F. C. BAUER, and L. H. SMITH



URBANA, ILLINOIS, JUNE, 1926

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.

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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 Saline county was conducted, and Mr. H. C. Wheeler, who as leader of the field party, was in direct charge of the mapping.

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SUPPLEMENT

SALINE COUNTY SOILS

By R. S. Smith, E. A. Norton, E. E. DeTurk, F. C. Bauer and L. H. Smith[1]

LOCATION AND CLIMATE OF SALINE COUNTY

Saline county is located in the southeastern part of Illinois, 18 miles west of the junction of the Wabash and Ohio rivers. The county is rectangular in shape, 21 miles long and 18 miles wide, comprizing an area of 386 square miles. With the exception of a belt of high, rough land in the south portion, the county lies within the lower extremity of the glaciated region of the state.

The climate of Saline county is characterized by a wide range between the extremes of winter and summer, and by an abundant, well-distributed rainfall. The greatest range of temperature in any year from 1899 to 1923 was 128 degrees in 1918. The lowest temperature recorded during the entire period was —22° in 1899; the highest, 110° in 1918. The average date of the last killing frost in spring is April 14; the earliest in fall, October 24. The length of the growing season, therefore, is about 193 days.

The average annual precipitation in the county for the 24-year period from 1899 to 1923 was 44.67 inches. The average annual rainfall by months for this period was as follows: January, 4.15 inches; February, 2.79; March, 4.38; April, 4.11; May, 4.15; June, 3.51; July, 3.84; August, 4.66; September, 3.33; October, 2.90; November, 3.14; December, 3.71. The proportion of rainfall occurring during each season was: winter, 23.8 percent; spring, 28.2 percent; summer, 27.1 percent; autumn, 20.9 percent.

AGRICULTURAL PRODUCTION

Agriculture and mining are the two important industries in Saline county. Agriculture probably is first in importance because it employs more people, the total value of its product is as large, and practically the entire area of the county is utilized in its pursuit. The system of farming which has been practiced since the county was settled has been that of general grain farming, and as a whole it has been profitable. Some farms, however, have been abandoned and more are being abandoned each year because the land has passed the point of marginal utility; that is, the point at which, under present conditions of agriculture, they can be profitably operated. One-third of the acreage in the county is not suited to general grain farming, and unless some specialized crops are introduced this large acreage will pass the point of being profitable and become submarginal land. The areas referred to as marginal lands are the rough and rocky hillsides, the slopes from which fertile surface soil is removed each year by erosion, and land which has been so farmed that it no longer produces profitable crops. Special crops which are adapted to this marginal land are pasture, fruit, and forest.

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[1] R. S. Smith, in charge of soil survey mapping; E. A. Norton, first assistant in 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.

In 1919, as shown by the Fourteenth Census, there were 2,105 farms in Saline county, these having an average of 97 acres each, 84.2 acres of which were improved. In 1900 the number of farms reported was 2,912, showing a rapid decrease during the two decades. Tenantry also decreased 50 percent during this time, 76.3 percent of the farms being operated in 1919 by the owners.

The principal crops are corn, wheat, oats, cowpeas, pasture, and hay. The Census reports the following acreage and yield of the more important crops.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn	34,342	692,567 bu.	20.0 bu.
Wheat	29,276	387,403 bu.	13.0 bu.
Oats	11,295	208,270 bu.	18.0 bu.
Barley	16	156 bu.	9.7 bu.
Rye	265	1,800 bu.	6.8 bu.
Timothy	8,279	9,839 tons	1.2 tons
Timothy and clover mixed	4,398	5,084 tons	1.1 tons
Clover	3,025	3,549 tons	1.2 tons
Alfalfa	876	1,421 tons	1.6 tons
Silage crops	342	1,472 tons	4.3 tons
Corn for silage	2,730	5,955 tons	2.1 tons

Within the past few years the cowpea, grown for both hay and seed, has been rapidly establishing itself as one of the staple crops of the region. The total value of the grains, hay and seed, produced in 1919 was slightly more than three million dollars. It must be remembered that these figures are for but a single year, that of 1919, which appears to have been a poor crop year for corn and oats. The U. S. Department of Agriculture reports the following acre-yields for the ten-year period 1911-1920, for Saline county: corn, 26.8 bushels; oats, 23.9 bushels; tame hay, 1.04 tons; winter wheat, 13.0 bushels.

The livestock interests, including those of dairy and poultry, are of importance, as is shown by the following data, also taken from the 1920 Census.

Animals and Animal Products	*Number*	*Value*
Horses	5,697	$538,225
Mules	3,289	382,899
Beef cattle	4,578	219,710
Dairy cattle	7,313	391,272
Sheep	1,995	26,284
Swine	17,210	218,967
Poultry	159,723	141,964
Eggs and chickens	....	416,861
Dairy products	....	277,376
Wool	5,219 lbs.	2,939

The report gives the total value of livestock as more than two and one-half million dollars.

Very little interest has been shown in the growing of fruit until the past few years. Prior to 1920 no fruit was grown for sale outside the county; since then orchards have been set out and have returned good profits. About 52,000 quarts of small fruits were produced in 1919. The total production of orchard fruits—namely, apples, pears, peaches, and cherries—was approximately 80,000 bushels, three-fifths of which were apples. Thirty thousand pounds of grapes were produced.

SOIL FORMATION

GEOLOGICAL HISTORY

A belt of high, rough land, which is commonly referred to as a spur of the Ozarks, enters Saline county in the southwestern corner, stretching across the southern tier of townships in a northeasterly direction. The history of this area dates back to the later Paleozoic period of geological time. It was not covered by any advance of ice during the Glacial period, and for that reason is termed unglaciated. The surface rocks of this area have been exposed to the processes of weathering longer than those in other parts of the state. This area is the result of a series of uplifts, the remains of which are shown by disconnected plains of about the same level and extent. The first uplift now forming the crest of the ridge appears in Saline county in the southeastern corner. The few isolated peaks forming the remnants of this plain stand about 1,000 feet above sea level, and are the highest points in the county. These ridges are made up of diverse rocks, the remaining high knobs being resistant sandstone, while limestone and shales, which are more easily weathered, form the valleys.

The most important period in the geological history of that part of the county north of this rugged area is known as the Glacial period. At that time snow and ice accumulated in the region of Labrador and to the west of Hudson Bay to such an amount that the mass pushed outward from these centers, chiefly southward, until a point was reached where the ice melted as rapidly as it advanced. In moving across the country from the far north, the ice gathered up all sorts and sizes of materials, including clay, silt, sand, boulders, and even immense masses of rock. Some of these materials were carried for hundreds of miles and rubbed against surface rocks and against each other until largely ground to powder.

A pressure of 40 pounds a square inch is exerted by a mass of ice 100 feet thick, and these ice sheets were hundreds, or possibly thousands, of feet in thickness. The material carried along in the ice, especially the boulders and pebbles, became powerful agents for grinding and wearing away the surface over which the ice passed. Preglacial ridges and hills were rubbed down, valleys filled with debris, and the surface features were changed entirely. The mixture of materials deposited by the glacier is known as boulder clay, till, glacial drift, or simply drift. The average depth of this deposit over the state of Illinois is estimated at more than one hundred feet.

During the Glacial period at least six distinct ice advances occurred that were separated by long periods of time. Only one of these, designated as the Illinoisan, reached Saline county. All the county except the rugged area lying south of the valley of the South Fork of Saline river was covered by this glacier. Previous to the ice invasion the glaciated region generally was not well suited to agriculture because of its rough and hilly character, as is shown by numerous borings which indicate that erosion had completely dissected the land. The general effect of the glaciers was to change the surface from hilly to gently undulating. Erosion has since continued active and has changed the topography in some areas from undulating back to hilly again.

The deposit of drift left by the Illinoisan glacier varied in depth from a few inches on the tops of old knolls or hills to a depth of 50 to 100 feet in old stream valleys. The drift was a heavy, sandy, gravelly, compact clay, originally blue but now more yellowish, owing to weathering. When the limit of the advance of the Illinoisan glacier was reached, the material carried by the glacier did not accumulate in a broad undulating ridge or moraine, as was the case with other glacial advances, because the thickness of the glacier and the amount of material it carried were greatly reduced by the time it reached Saline county, and its recession was gradual and uniform rather than intermittent, as was the case of those glaciers which built up moraines.

Another important process took place during and shortly after the Glacial period, which furnished a large part of the soil material from which the present soils were derived. During the melting of the glaciers, the Illinoisan as well as subsequent ones, the streams were overloaded with rock flour produced by the grinding action of the glacier. This rock flour was deposited in the stream valleys, and after the streams regained their former channels, it dried, was picked up by the wind, and was rather uniformly deposited over the upland as dust. Saline county received its share of this wind-blown material, called loess, which buried the older deposits to a depth varying from one to twenty feet.

The broad, flat valleys which are found along the main drainage courses are not the result of stream erosion since the Glacial period. Altho the Illinoisan glacier, in its advance across Saline county, covered the land with a deposit varying from a few inches to more than 100 feet, the deposit had little effect on the present general drainage of the county. The main drainage channels were reestablished along Preglacial lines and the streams have taken meandering courses thru these broad valleys which have been filled to a depth of 50 to 100 feet with drift. These valleys are termed Preglacial because they are the result of stream erosion since the area was first lifted out of the sea at a very early geologic period. The Preglacial valleys comprize more than one-third of the total area of the county, and contain the more fertile and productive soils.

PHYSIOGRAPHY AND DRAINAGE

Saline county has extremes in topography which are due primarily to the rugged, hilly character of the Ozark highlands. This area is extremely rough and broken; erosion has dissected the once extensive plains until now only a few very narrow ridges remain as comparatively level land. The glaciated area to the north of the Ozark ridge is flat to gently rolling except for a few areas along the west side of the county which are rolling to rough. The broad stream valleys are nearly level, the bordering lowlands undulating, and the upland gently rolling.

The altitude of Saline county varies from 980 feet above sea level to 340 feet, a difference of more than 600 feet. The highest point is on Horton Hill near the southern part of Sommerset township, (Township 10 South, Range 7 East); the lowest point is found where Saline river leaves the county. The following figures give the altitudes of a few points in the county: Bald Knob, 820 feet;

Eldorado, 385; Francis Mills, 371; Galatia, 416; Harrisburg, 366; Horton Hill, 980; Raleigh, 418; Rileyville, 393; Rudemont, 400; Sommerset, 446.

The county lies entirely within the drainage basin of Saline river, the waters of which flow east, emptying into the Ohio river. South Fork drains the three southern townships with the exception of the east half of Sommerset township (Township 10 South, Range 3 East), which is drained by Eagle creek; Middle Fork with its tributary, Bangston creek, drains the central and western parts of the county; and North Fork with its tributary, Rector creek, drains the northeastern part of the county. South Fork and Middle Fork unite just east of the center of the county to form Saline river.

The county is generally well drained, each of the larger streams having numerous tributaries which drain every section. Judging from the ramification of streams, the amount of erosion, and the breadth and depth of stream valleys, the drainage of Saline county would be classed as mature. The unglaciated area drains particularly well, owing to the hilly topography. The problem here is not one of drainage but one of controlling the erosion which occurs as a result of surface run-off. Except for a few flat areas the glaciated upland drains well, erosion becoming a problem on the more rolling topography. Heavy spring rains

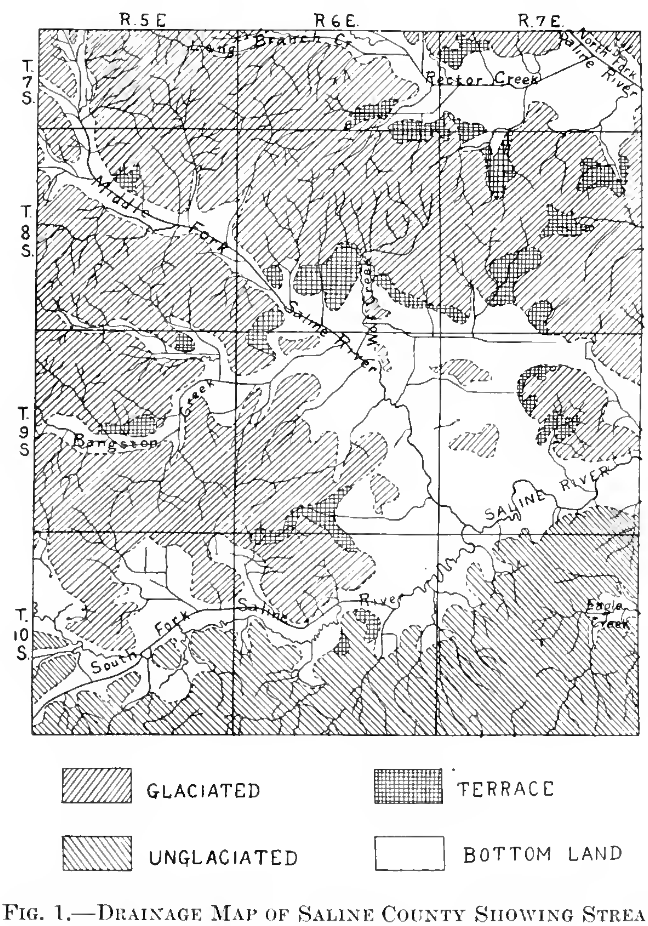


FIG. 1.—DRAINAGE MAP OF SALINE COUNTY SHOWING STREAM COURSES, GLACIATED AND UNGLACIATED AREAS, TERRACE, AND BOTTOM LAND

fill the stream channels and the streams frequently overflow the surrounding bottom land, making shallow lakes which do not dry up until summer. Extensive dredging has improved this condition materially, but more improvement could be effected, especially by deepening and widening those dredges already in. The system should be extended until it reaches every farm, since much of the land in these broad valleys remains swampy thruout the year.

SOIL DEVELOPMENT

Rocks weathered in place, glacial till, and loess are the three sources of soil material from which the present upland soils of Saline county were derived. The present soil is thought to have been derived mainly from material of loessial origin. On the stony slopes in the unglaciated part of the county are some areas where the soil material is a mixture of residual and loessial material, and might properly be termed residuo-loessial or residuo-æolial. Erosion has, subsequently, removed the loess from some of the hilly areas in the glaciated region so that the till forms the soil material in those areas.

The general composition of any soil material, particularly loess, is rather uniform when first deposited. The various physical, chemical, and biological agencies of weathering form soil out of soil 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 layers, zones or horizons; and 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 distinct layers, strata, or horizons, and so, as explained on page 22, 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. Bottom-land soils which are constantly receiving deposits washed down from the adjoining hills are called young soils; new soil material is added so frequently that the process of weathering does not have time to form distinct horizons. Some of the areas in the broad preglacial bottom lands of Saline county do not overflow often and have not received any additional deposit of consequence for many years; the soils in these areas have developed horizons but they are not so mature as those of the upland.

SOIL GROUPS

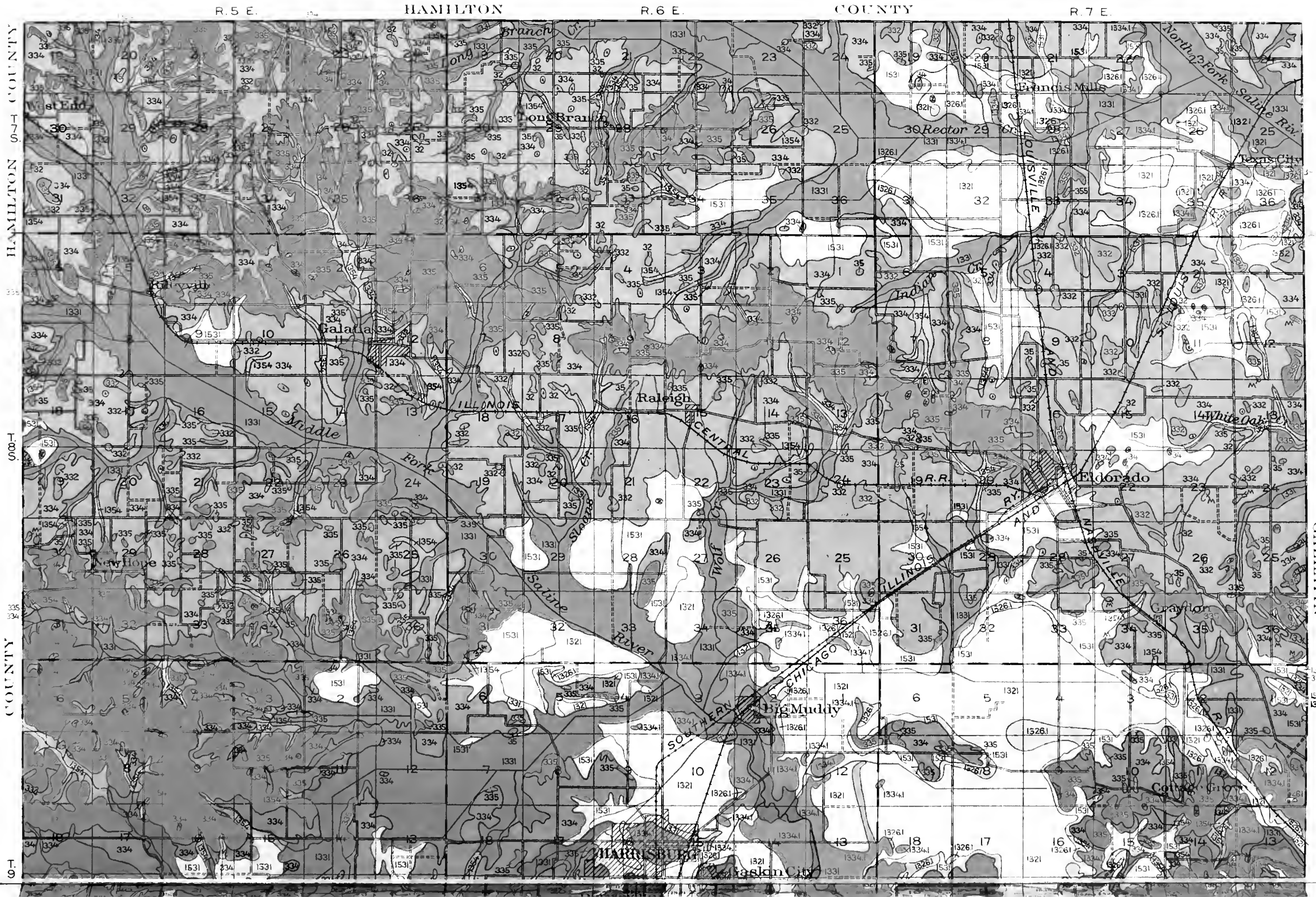
The soils of Saline county are divided into four groups, as follows:

Upland Timber Soils, including all the upland areas of glacial or loessial origin, that are now, or were formerly, covered with timber.

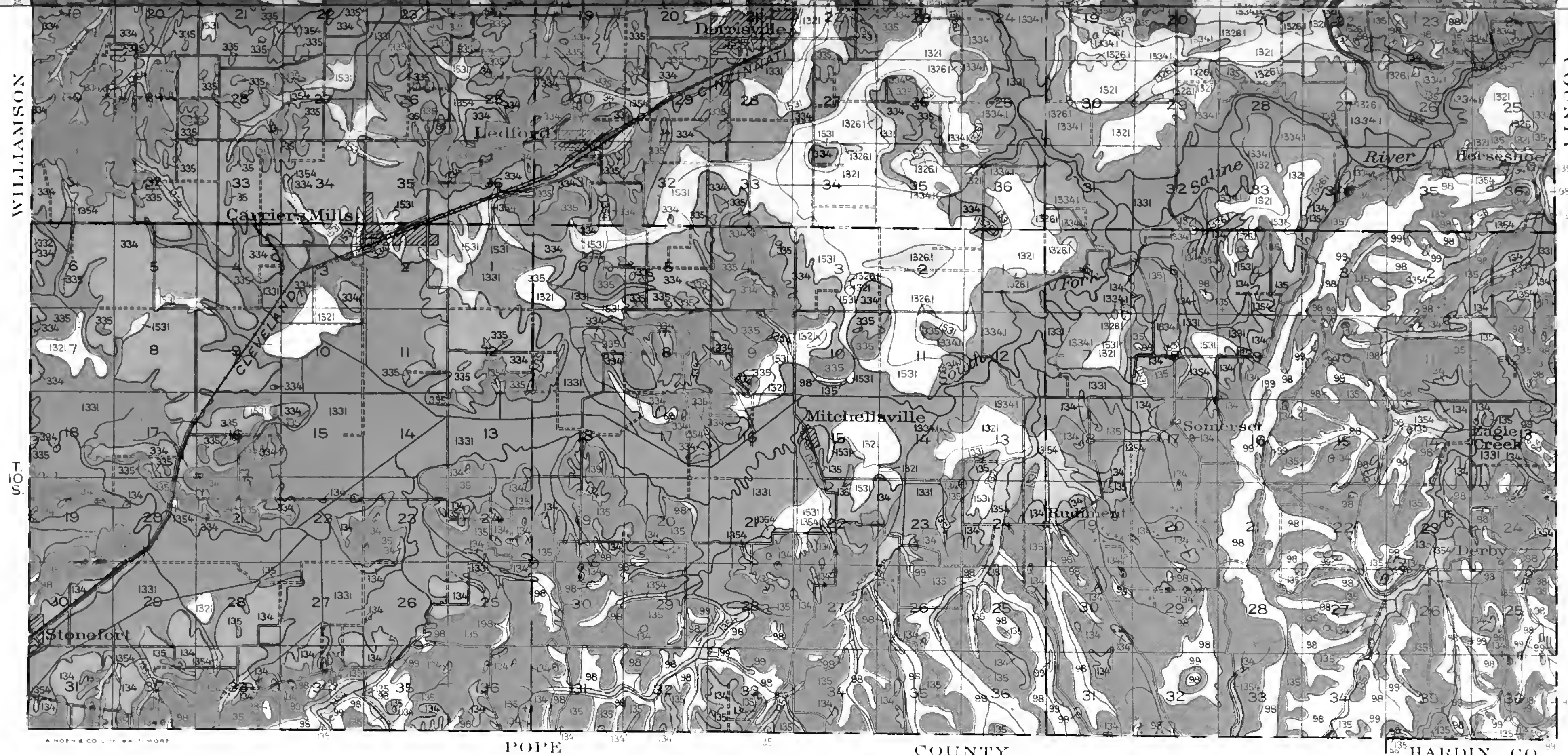
Terrace Soils, including bench lands, or second bottom lands, formed by deposits from overloaded streams.

Swamp and Bottom-Land Soils, including the overflow land along streams, the swamps, and poorly drained lowlands.

Residual Soils, including rock outcrops, and soils formed in place thru the weathering of rocks.



HAMILTON COUNTY
GALLATIN
R.5 E.
R.6 E.
R.7 E.
T. 7 S.
T. 8 S.
T. 9
Eldorado
Raleigh
Galatia
Harrisburg
Big Muddy
New Hope
Francis Mills
Texas City
Cottage Grove
Long Branch
Rector Cr.
Middle Fork
Saline River
North Fork Saline Riv.
White Oak
Indian Cr.
Wolf Cr.
ILLINOIS CENTRAL R.R.
LOUISVILLE AND NASHVILLE
CHICAGO SOUTHERN



LEGEND

000 Residual
100 Unglaciated Areas
300 Lower Illinoisan Glaciation

Scale
0 ¼ ½ 1 2 Miles

UPLAND TIMBER SOILS

- Z 34 134 334 — Yellow-Gray Silt Loam
- M 35 35 335 — Yellow Silt Loam
- 32 332 — Light Gray Silt Loam On Tight Clay

1500 TERRACE SOILS

- 1531 — Deep Gray Silt Loam

CONVENTIONAL SIGNS

- Railroads
- Public Roads
- Private Roads
- Township Lines

1300 OLD SWAMP AND BOTTOM-LAND SOILS

- 1331 — Deep Gray Silt Loam
- Y 1354 — Mixed Loam
- 1321 — Drab Clay Loam
- 13341 — Yellow-Gray Silt Loam On Clay
- 13261 — Brown Silt Loam On Clay

RESIDUAL SOILS

- 98 098 — Stony Loam
- 99 099 — Rock Outcrop
- Small Areas Of Stony Loam
- Small Areas Of Rock Outcrop

SOIL SURVEY MAP OF SALINE COUNTY

UNIVERSITY OF ILLINOIS AGRICULTURAL EXPERIMENT STATION

TABLE 1.—SOIL TYPES OF SALINE COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Upland Timber Soils (100, 300)			
134 334	Yellow-Gray Silt Loam	119.40	76 416	30.88
135 335	Yellow Silt Loam	91.58	58 611	23.68
332	Light Gray Silt Loam On Tight Clay	2.80	1 792	.72
		213.78	136 819	55.28
	Terrace Soils (1500)			
1531	Deep Gray Silt Loam	22.77	14 573	5.89
	Old Swamp and Bottom-Land Soils (1300)			
1331	Deep Gray Silt Loam	70.20	44 928	18.15
1354	Mixed Loam	11.59	7 418	3.00
1321	Drab Clay Loam	30.17	19 309	7.80
1334.1	Yellow-Gray Silt Loam On Clay	16.21	10 374	4.19
1326.1	Brown Silt Loam On Clay	8.96	5 734	2.32
		137.13	87 763	35.46
	Residual Soils (000)			
098	Stony Loam	12.45	7 968	3.22
099	Rock Outcrop	.57	365	.15
		13.02	8 333	3.37
	Total	386.70	247 488	100.00

Table 1 gives a list of the soil types found in Saline county, classified according to the groups described above. It also shows the area of each type in square miles and in acres and its percentage of the total area of the county. The accompanying map shows the location and boundary lines of every type of soil in the county, even down to areas of a few acres in extent.

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

INVOICE OF THE ELEMENTS OF PLANT FOOD IN SALINE 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 surface, subsurface, and subsoil. By this system of sampling we have represented separately three zones for plant feeding. The upper, or surface layer, includes at least as much soil as is ordinarily turned with the plow, and this is the part with which the farm manure, limestone, and other fertilizing materials are 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 an acre of soil to a depth of 6⅔ inches weighs 2 million pounds. It is understood, of course, that this value is only an approximation, but with this understanding it is believed that 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 defferent 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 follows, 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 29).

THE UPPER SAMPLING STRATUM

In Table 2 are reported the amounts of organic carbon and the total quantities of nitrogen, phosphorus, sulfur, potassium, magnesium, and calcium in 2 million pounds of the surface soil of each type in Saline 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 a variation in the organic-carbon content of the different soils is accompanied by a parallel variation 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 close 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.

The organic matter, with the accompanying nitrogen, shows some variation among the different soil types but is comparatively low thruout the county. Of the nine types of soil for which analyses are reported in this county, only one contains more than 40,000 pounds of organic carbon in the surface stratum of an acre. This is Drab Clay Loam, Bottom, which contains 46,410 pounds of this element, with a corresponding nitrogen content of 3,710 pounds an acre. The remainder of the soils in the county range from 34,480 pounds of organic carbon in Brown Silt Loam On Clay, down to 15,720 pounds in Yellow Silt Loam. The total nitrogen values are correspondingly low, being in the two latter types 2,800 and 1,340 pounds respectively. Because of the small amounts of both nitrogen and organic matter in these soils, it is particularly important to grow legume crops frequently as green manures and plow them down, in addition to conserving and using all the animal manure which can be produced.

Other elements are not so closely associated with each other as organic matter and nitrogen. There is some degree of correlation, however, 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. The sulfur content of Saline county soils is generally low. It ranges, in the surface soil, from 60 to 660 pounds an acre, averaging less than half the phosphorus content. The proportion is still lower in the deeper layers of soil. This is partly accounted for by the low organic matter. Another factor is the atmospheric supply. 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 has been added to soil by the rainfall 3.5 pounds of sulfur an acre a month as an average. Similar observations have been made in localities in southern Illinois for shorter periods. At Newton, in Jasper county, in 1921 there was added in the rainfall 2.52 pounds of sulfur an acre in June and 3.75 pounds in September. At Ewing, Franklin county, during the season of 1921 the average monthly precipitation contained 2.27 pounds of sulfur an acre. These 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 there is probably no need for sulfur fertilizers in Saline county. Because of the possibility of a need for sulfur fertilization in some parts of the state, experiments with gypsum have been started on five experiment fields, namely, Raleigh, Toledo, Carthage, Hartsburg, and Dixon. The first two named fields are located in southern Illinois, in Saline and Cumberland counties, respectively.

TABLE 2.—PLANT-FOOD ELEMENTS IN THE SOILS OF SALINE 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 Timber Soils (100, 300)							
134 334	Yellow-Gray Silt Loam	21 570	2 110	860	350	24 230	5 210	4 670
135 335	Yellow Silt Loam	15 720	1 340	660	280	30 490	6 420	4 440
332	Light Gray Silt Loam On Tight Clay	17 720	1 620	680	340	25 480	4 600	5 140
	Terrace Soils (1500)							
1531	Deep Gray Silt Loam	24 710	2 360	970	380	30 720	6 170	6 720
	Old Swamp and Bottom-Land Soils (1300)							
1331	Deep Gray Silt Loam	20 490	2 160	1 100	460	33 890	7 080	5 060
1354	Mixed Loam[1]	......	......	......	......	......	......	......
1321	Drab Clay Loam	46 410	3 710	1 280	660	40 790	14 230	16 250
1334.1	Yellow-Gray Silt Loam On Clay	21 920	1 760	850	420	33 750	7 410	5 800
1326.1	Brown Silt Loam On Clay	34 480	2 800	820	440	35 580	10 480	13 100
	Residual Soils (000)							
098	Stony Loam	19 960	1 180	520	60	22 880	4 040	4 300
099	Rock Outcrop[2]	......	......	......	......	......	......	......

LIMESTONE AND SOIL ACIDITY.—In connection with these tabulated data it should be explained that the figures for limestone content and soil acidity are omitted not because of any lack of importance of these factors, but rather because of the peculiar difficulty of presenting in the form of general numerical averages reliable information concerning the limestone requirement for a given soil type. A general statement, however, will be found concerning the lime requirement of the respective soil types in connection with the discussions which follow.

[1]On account of the heterogeneous character of Mixed Loam, chemical analyses are not included for this type.
[2]No samples taken.

The phosphorus content of the soils in the county is low, on the whole, averaging only about 850 pounds an acre in the surface soil. Drab Clay Loam contains 1,280 pounds an acre of this element, while the minimum, 520 pounds, is found in Stony Loam. Considering the low phosphorus level in these soils it appears that the renewal of this element by the addition of phosphate will be a necessary step in the permanent improvement of the soil.

The potassium content of the soil ranges from 22,880 pounds an acre in Stony Loam to 40,790 pounds in Drab Clay Loam. From a quantitative point of view the least of these amounts is far above maximum crop requirements. However, the rate at which potassium is liberated in available condition from these large reserves is slow, and in soils so low in organic matter as is the case here the rate of liberation may be too slow to supply the needs of growing crops. The results of field experiments as given in the Supplement are an indication that potassium fertilization may be desirable, at least for some crops on some of the soils of Saline county.

The amounts of soil calcium are, on the whole, rather low, but no lower than is to be expected in old, leached soils which are strongly acid. Soil acidity and calcium deficiencies are very frequently, but not always, associated. The

TABLE 3.—PLANT-FOOD ELEMENTS IN THE SOILS OF SALINE 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 Timber Soils (100, 300)							
134, 334	Yellow-Gray Silt Loam	23 930	2 710	1 530	510	54 520	16 260	8 160
135, 335	Yellow Silt Loam	16 830	1 760	1 470	530	63 510	17 620	8 720
332	Light Gray Silt Loam On Tight Clay	14 040	1 320	1 160	360	51 880	11 240	9 720
	Terrace Soils (1500)							
1531	Deep Gray Silt Loam	24 140	2 460	1 420	600	61 840	13 360	11 960
	Old Swamp and Bottom-Land Soils (1300)							
1331	Deep Gray Silt Loam	18 340	2 440	1 740	640	70 020	14 570	9 970
1354	Mixed Loam[1]	....	......	......	......	....	....	....
1321	Drab Clay Loam	56 460	4 730	1 930	790	81 290	27 960	24 900
1334.1	Yellow-Gray Silt Loam On Clay	18 580	1 720	1 400	780	74 040	20 860	8 320
1326.1	Brown Silt Loam On Clay	41 280	3 400	1 120	840	70 040	22 960	23 240
	Residual Soils (000)							
098	Stony Loam[2]	....	......	......	......	....	....	....
099	Rock Outcrop[3]	....	......	......	......	....	....	....

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

[1]On account of the heterogeneous character of Mixed Loam, chemical data for this type are not included.
[2]The stony character of this type prevented the sampling of the middle stratum.
[3]No samples taken.

smallest amount of calcium, 4,300 pounds an acre, is in Stony Loam; but this amount, with two exceptions, is about the same as that in all the other types. These two exceptions are Brown Silt Loam On Clay, with 13,100 pounds, and Drab Clay Loam, with 16,250 pounds. Both of these are bottom-land types which are neutral or alkaline. Calcium is utilized by crops in fairly large amounts, so that in soils low in calcium content this element may not become available rapidly enough to supply crop needs. The liming of such soils, however, supplies any calcium deficiencies in addition to the correcting of acidity.

The surface soil in Saline county contains, on the average, approximately the same quantity of magnesium as of calcium. The smallest amount found is 4,040 pounds an acre and the maximum 14,230 pounds. Because of the relatively small quantities of this element required by crops, it is doubtful, even in soils containing the minimum, whether it ever becomes a limiting factor in crop growth. Moreover, any possible deficiencies of this element for crop growth in the surface soils are offset by the accumulations in the lower strata, as explained in the following section.

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

TABLE 4.—PLANT-FOOD ELEMENTS IN SOILS OF SALINE 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 Timber Soils (100, 300)							
134, 334	Yellow-Gray Silt Loam........	19 420	2 390	2 350	570	94 730	34 470	18 540
135, 335	Yellow Silt Loam.............	12 210	1 780	2 050	890	96 090	27 810	15 880
332	Light Gray Silt Loam On Tight Clay....................	14 460	1 560	1 860	60	84 720	27 000	15 840
	Terrace Soils (1500)							
1531	Deep Gray Silt Loam..........	24 240	2 940	1 920	360	97 800	27 030	20 220
	Old Swamp and Bottom-Land Soils (1300)							
1331	Deep Gray Silt Loam..........	17 170	2 760	2 200	540	107 220	22 210	15 250
1354	Mixed Loam[1]................	......	......	......	......	......	......	......
1321	Drab Clay Loam...............	49 710	4 780	2 730	1 000	120 210	50 790	45 700
1334.1	Yellow-Gray Silt Loam On Clay	20 730	2 430	2 430	1 830	120 060	47 220	17 880
1326.1	Brown Silt Loam On Clay......	37 440	3 720	2 160	680	109 740	50 340	48 360
	Residual Soils (000)							
098	Stony Loam[2]................	......	......	......	......	......	......	......
099	Rock Outcrop[3]..............	......	......	......	......	......	......	......

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

[1]On account of the heterogeneous character of Mixed Loam, chemical data for this type are not included.
[2]The stony character of this type prevented the sampling of the lower stratum.
[3]No samples taken.

and 6 million pounds of soil, and should, therefore, be divided by two and three respectively before being compared with each other or with the data for the upper stratum, which is on a basis of 2 million pounds.

With this in mind it will be noted in comparing the three strata with each other that all the soil types diminish rather rapidly in organic matter and nitrogen with increasing depth, and that this diminution is very marked even in the middle stratum. The sulfur content decreases markedly with increasing depth. 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. Thus, in the eight soil types in Saline county analyzed, the second stratum contains proportionately a smaller amount of phosphorus than the surface.

The basic elements have all been leached from the surface soil to some extent. Potassium and magnesium show increases in the second stratum and are still more concentrated in the lowest. As these bases are dissolved from the surface soil and pass downward by percolation, they are in part fixed in the lower levels by reconversion into insoluble forms. Calcium is less readily fixed than magnesium. Consequently the latter forces calcium out into the solution so that it is carried down to lower levels or lost entirely. It is to be noted that in nearly all the soil types in Saline county the accumulation of calcium occurs only in the lowest stratum or not at all, while magnesium and potassium exhibit increases in concentration also in the second stratum.

It is frequently of interest to know the total supply of a plant-food element within reach of the roots of growing crops. While it is impossible 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.

Considered in this manner the tables reveal a wide variation with respect to the relative abundance of the various elements among the different soil types, as measured by crop requirements. We may compare in this way two extreme soil types in the county, namely, Drab Clay Loam, Bottom, and Yellow Silt Loam, Upland. These are among the most extensive soil types in the county. The respective amounts of nitrogen in the two soils to a depth of 40 inches are 13,220 and 4,880 pounds an acre, which is equivalent to the nitrogen contained in the same number of bushels of corn, since a bushel of corn contains approximately a pound of nitrogen. Drab Clay Loam thus contains nearly three times as much of this element as Yellow Silt Loam. Drab Clay Loam also contains considerably more phosphorus than Yellow Silt Loam. The former contains 5,940 pounds of phosphorus, which is equivalent to 34,900 bushels of corn, as compared to 4,180 pounds in the latter, equivalent to 24,600 bushels of corn. A comparison of total amounts of potassium in the two soil types is of little moment when it is considered that the soil with the lowest content of this element, namely, Light Gray Silt Loam On Tight Clay, contains potassium equivalent to 850,000 bushels of corn. This large total supply of potassium does not mean that there can be no need for potassium fertilizers. The supply in the soil may not become available rapidly enough for the demands of crops during the growing season, and therefore in some cases applications of potassium may prove beneficial.

These two soil types vary widely in calcium content, the amounts contained to a depth of 40 inches being 86,850 pounds in Drab Clay Loam and only 29,040 pounds in Yellow Silt Loam. The relative amount of calcium is not of so great importance directly in connection with the corn crop as it is with respect to legumes. A ton of red clover hay, for example, contains approximately 29 pounds of calcium. These two soils therefore contain as much calcium as would be removed in 2,990 and 1,000 tons of red clover hay respectively.

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 than the amount of plant-food elements present enter into consideration.

Much depends upon the nature of the crops to be grown, as to their ability to utilize 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 chemical data 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 that will conserve and improve the fertility of the land.

DESCRIPTION OF SOIL TYPES

UPLAND TIMBER SOILS

The upland timber soils include all the upland areas of glacial and loessial origin that are now or were formerly covered with timber. In forests the vegetable material from trees falls on the surface of the ground and is either burned or suffers almost complete decay. Grasses, which furnish large amounts of humus-forming roots, do not grow to any extent because of the shade. Moreover, the organic matter that had accumulated before the timber invaded the territory is removed thru various decomposition processes, with the result that in these soils generally the content of nitrogen and organic matter is low. A yellowish or yellowish gray surface color is characteristic of timber soils in Illinois.

The total area of upland timber soils in Saline county is 213.78 square miles, or more than 55 percent of the area of the county.

Yellow-Gray Silt Loam (134, 334)

Yellow-Gray Silt·Loam has been formed under the influence of the long-continued growth of forests, which as a general rule develop along streams where drainage is good and gradually spread over the prairie as drainage becomes established. As this region is relatively old, ample time has elapsed for the timber to spread over the entire county. The topography of Yellow-Gray Silt Loam varies from undulating or nearly level to rolling. The topography of the area occupied by this type has been an important factor in the modification of certain horizons of the soil profile, producing different phases within the type. These phases are easily recognized, as (1) the undulating phase, whose soils have a distinct gray cast, and a compact to tight subsoil; (2) the rolling phase, whose soils are more yellowish, and not so compact. The rolling phase of Yellow-Gray Silt Loam is well drained naturally; it is much better drained than the undulating phase. The zone of accumulation, that is, the upper subsoil or B horizon, in the undulating phase is compact to tight and the soil is poorly aerated and poorly underdrained.

Yellow-Gray Silt Loam is the most extensive soil type in the county. It covers 119.4 square miles, or about 30 percent of the area of the county. The rolling phase includes all the areas of the type mapped in the unglaciated region, and those areas that occur on the slopes in the western part of the county and in the eastern part of Cottage Grove township (Township 9 South, Range 7 East).

Practically all the remaining areas of the type, except a few scattered ones, are included in the undulating phase.

The A_1 horizon, or surface soil, of the undulating phase of Yellow-Gray Silt Loam, 0 to 3 inches, or 6 to 7 inches when cultivated, is a brownish gray, friable silt loam. The A_2 horizon, or subsurface soil, 3 to 18 inches, is a light yellowish gray, mealy, friable silt loam. The B horizon, or upper subsoil, 18 to 34 inches, is a very compact to tight, well-mottled, yellow clay. Blotches of almost pure gray occur in the joints or cracks made by water percolating thru the soil. The C horizon, or lower subsoil, is a friable, mottled, yellow silt loam.

The A_1 horizon of the rolling phase of the Yellow-Gray Silt Loam, 0 to 5 inches, or 6 to 7 inches when cultivated, is a brownish yellow, friable silt loam. The A_2 horizon, 5 to 16 inches, is a friable, slightly mottled, yellowish gray silt loam. The B horizon, 16 to 30 inches, is a compact, grayish yellow, mottled, silty clay loam. The C horizon, below 30 inches, is a friable, yellow, mottled silt loam. The depth to till in the undulating phase of Yellow-Gray Silt Loam varies from 4 to 12 feet, while that in the rolling phase is more constant and averages about 5 feet.

Management.—The undulating phase of Yellow-Gray Silt Loam is not naturally well drained. It is usually medium to strongly acid in the surface soil and the degree of acidity increases with an increase in depth. It is low in organic matter and nitrogen. Red clover will not grow on this land unless it is either limed or heavily manured. Sweet clover will not grow without lime. Cowpeas do fairly well without lime and mixed clover and timothy hay yields well following the application of 3 to 4 tons of limestone per acre.

The results on the Raleigh experiment field, which is located on soil similar to much of this phase of the type, indicate that manure or residues without lime are not effective, but that if lime also is used the response of the crops is good. Rock phosphate has not caused sufficient increase in yields on this field to pay its cost. Potash has caused sufficient increase in yields to indicate that it is worth while to try small applications of one of the potash salts for corn. The outstanding requirements of this soil type are first lime and then fresh organic matter and nitrogen secured by the growth of clover, preferably sweet clover, and the use of all manure available. Further studies now in progress indicate that other treatments may prove profitable, in addition to those that can now be definitely recommended.

The rolling phase of Yellow-Gray Silt Loam is better drained than the undulating phase because of its more rolling topography and more pervious subsoil. It is similar to it in lime requirement except that the subsoil is probably always less acid, and it is also low in nitrogen and organic matter. The Elizabethtown experiment field is located on soil which is similar to this phase of the type. The results secured on this field indicate no improvement in yield from the use of manure or residues alone. A very marked increase in yield, however, follows the application of limestone with either manure or residues. Rock phosphate has produced a more beneficial effect on this field than on the Raleigh field, but the increase in yields resulting from its application are not sufficiently high to justify its unqualified recommendation for the soil under discussion. It can be stated, however, that the results from its use on this kind of soil are sufficiently good to indicate very strongly the wisdom of giving it a trial after the lime, nitrogen, and organic-matter deficiencies of the soil have been corrected. Comparative phosphate trials have been conducted on the Elizabethtown field for a short time. This work has not been in progress sufficiently long to warrant drawing conclusions. To date the differences shown are small. The potassium treatment on this field has been ineffective.

Yellow Silt Loam (135, 335)

Yellow Silt Loam is the predominating soil type in the unglaciated region, and is also well distributed over the remainder of the county. It occurs in very irregular areas as the broken and hilly land along streams, in the more rolling and rough upland, and on the steep slopes of ridges. It has been heavily timbered, and some of the timber has never been cut off. Yellow Silt Loam is the second most extensive soil type in the county and covers an area of 91.58 square miles.

The A_1 horizon, or surface soil, when present, is a reddish to brownish yellow, friable, silt loam. Sheet washing and gullying have removed the true surface soil in most cases. The A_2 horizon, or subsurface soil, is a yellowish gray, friable, silt loam, varying in thickness from 0 to 15 inches, depending on how much erosion has taken place. The B horizon, or upper subsoil, is a compact, mottled reddish yellow, silty clay loam, found at a depth of 15 to 30 inches in areas where erosion is not active. The C horizon, or lower subsoil, is a friable, yellow, mottled silt loam. Often in the glaciated areas glacial till forms the subsoil, and in the unglaciated areas, cherty, residual material is found.

Management.—The management of Yellow Silt Loam must be governed by the slope as well as by the character of the soil material of the particular area in question. A large proportion of the type is unsuited to ordinary farming because of its steep topography and consequent tendency to erode. The steepest portions should be utilized for timber growth; other portions are well adapted to orcharding, while still others can be made into excellent pastures provided limestone can be applied. The slopes which are not so steep as to present too difficult erosion problems may be farmed successfully if constant attention is given to controlling erosion. The results secured on the Vienna experiment field (see page 51 of the Supplement) may be taken as an indication of the success which will follow the use of limestone and good farming methods. This land, when treated with limestone, is particularly well adapted to hay, either clover or mixed clover and timothy. It also grows excellent cowpeas and fair wheat. It is not adapted to corn. The results from the Vienna field do not indicate that either rock phosphate or acid phosphate will be profitable on this soil when manure also is applied. No information is available as to whether either of these phosphates could be used profitably with a good rotation, including clover, when manure is not used.

Light Gray Silt Loam On Tight Clay (332)

Light Gray Silt Loam On Tight Clay is one of the poorest upland types in the county. It occupies only 2.8 square miles, occurring in the flat, poorly drained, timbered areas in the glaciated portion of the county. It is commonly referred to as "post oak or hickory flats," because post oak and hickory trees grow in abundance on the land. This type is too flat for proper surface drainage, the subsoil is so tight that underdrainage is impossible, and organic matter is deficient. It has a profile similar to that of Gray Silt Loam On Tight Clay, but differs from it in that the surface and gray layer are lighter in color and better developed, and that the B horizon or "tight clay," is less yellow and appears to be more plastic and impervious.

The A_1 horizon, or surface soil, of Light Gray Silt Loam On Tight Clay, 0 to 5 inches, is a friable, light yellowish gray silt loam. The A_2 horizon, or subsurface soil, 5 to 23 inches, is a friable, mealy, light gray silt loam. The B_1 horizon, or upper subsoil, 23 to 36 inches, is a gray clay mottled with light yellow. The C horizon, or lower subsoil, below 36 inches, is a slightly compact, well-mottled, yellowish gray silt loam. The till is encountered at an average depth of 6 feet. The low organic-matter content of this type makes it run together during heavy rains. The soil works fairly well when moist but bakes very hard on drying. The surface is somewhat porous and incoherent. Hydrated iron oxide concretions are usually found in abundance on this soil type.

Management.—Light Gray Silt Loam On Tight Clay is strongly acid and very low in nitrogen and organic matter. It is not a good general farm soil because of unfavorable moisture conditions resulting from its highly impervious nature.

Results obtained on the Sparta experiment field which is located, for the most part, on Light Gray Silt Loam On Tight Clay, indicate that limestone is essential on this type. Manure when used alone causes but little increase in yield, but limestone and manure together, or limestone and crop residues, cause a sufficient increase in yield to return a profit on the money invested in limestone. Neither rock phosphate nor potash caused sufficient increase in yield to pay for their cost. See page 47 of the Supplement for further discussion of the Sparta experiment field.

Attention should be called to the fact that the areas of this soil type in Saline county are flat, while the Sparta field has sufficient slope so that good surface drainage can be provided. This difference in topography suggests that the Saline county areas will not respond to any treatment so well as the Sparta field does. Further, it is questionable whether an attempt should be made to use this type for general farming. The gross returns, even under the best treatment, are small. It is suggested that it be used either for apples or for pasture with sweet clover as the pasture crop.

TERRACE SOILS

The terrace soils of Saline county occur either as bench land along stream valleys, or just above overflow in the valley itself. The bench-land terraces were formed chiefly by the deposition of silt washed down from the surrounding upland, mixed with some alluvial deposit carried in many years ago. Swollen and overloaded streams caused by the melting of the glacier, and subsequent heavy rains, flooded the valleys and filled them to a depth of 10 feet or more with an alluvial deposit. Gradually the streams cut deeper channels thru this deposit, leaving parts of it above overflow. These parts are known as terraces or second bottoms. In Saline county there is but a single terrace type, Deep Gray Silt Loam (1531), and it occupies 22.77 square miles.

Deep Gray Silt Loam (1531)

Deep Gray Silt Loam, Terrace, is found for the most part along small creeks, and is rather generally distributed over the county. A few areas included in this type overflow in exceptionally high water. Not enough deposit is left, however, to change the soil, as most of the water rises from the immediate vicinity and is gone in a few hours. The soil profile of this type is in various stages of development, depending primarily upon the length of time which has elapsed since the deposition of the soil material. In general, the formation is relatively young in comparison with the mature upland. The more mature profile has the following description: the A_1 horizon, or surface soil, 0 to 4 inches, is a friable, yellowish gray silt loam; the A_2 horizon, or subsurface soil, 4 to 18 inches, is a friable, light gray silt loam; the B horizon, or upper subsoil, 18 to 24 inches, is a compact, somewhat plastic, gray clay loam. Often this layer is only partially developed. The younger soils which have no horizons developed are predominantly gray in color and silty in texture.

Management.—Deep Gray Silt Loam, Terrace, varies somewhat in lime requirement depending on whether it is subject to overflow. Those portions of the type which are overflowed at least once a year are either neutral or only slightly acid in the surface soil. The non-overflow portions of the type are usually medium acid in the surface. The subsoil of both the overflow and non-overflow portions is more strongly acid than the surface soil. This type is one of the best soils in Saline county. It needs lime, as indicated above, and is low in organic matter and nitrogen. No special treatment is advised at the present time other than attention to drainage, the use of limestone in such amounts as tests show are needed, and the use of leguminous crops, together with all the manure available.

OLD SWAMP AND BOTTOM-LAND SOILS

The most fertile land in Saline county is found in the broad, flat valleys. Most of it is an alluvial formation and is largely subject to overflow. Each overflow brings in some new deposit which serves continually to enrich the soil. The overflows do some damage to property, especially to growing crops, but they do not cause extensive damage as they usually occur in early spring before the land is prepared for crops, and recede quickly. This group of soils found in the valleys includes the bottom land along streams, the swamps, and the poorly drained lowlands. Drainage is the most important factor in the use of this land for agricultural purposes. In wet seasons water stands in all the low spots and on the level land, so saturating the soil for extended periods that plant development is seriously hampered. Dredging and tiling have relieved the condition in some areas. More of this work could profitably be done.

This group of soils is divided into five types which cover an area of 137.13 square miles, or about 35 percent of the total area of the county.

Deep Gray Silt Loam (1331)

Deep Gray Silt Loam is the common bottom-land soil of southern Illinois. It is generally distributed over this county and occupies areas varying in width from a few rods to more than a mile. It usually forms the overflow land immediately adjacent to streams. It overflows several times almost every year, and often receives a slight deposit of new material. Deep Gray Silt Loam, Bottom, covers an area of 70.2 square miles.

A soil which is continually receiving new deposit is not uniform, has no well-defined horizons, and is spoken of as a young soil. Deep Gray Silt Loam, Bottom, is a young soil and, as it varies considerably thruout its area, can be described only in general terms.

The surface soil, averaging about 6 inches but varying from 2 to 12 inches, is a friable, light yellowish gray silt loam. The areas near the present stream channels sometimes contain an appreciable amount of fine sand to a depth of 4 or 5 inches. Below the surface the soil is a friable, mealy, light gray silt loam. Areas which do not receive frequent deposits have developed a compact, silty clay horizon 2 or 3 inches thick which lies about 20 inches below the surface.

Management.—Deep Gray Silt Loam, Bottom, is a productive soil when the moisture conditions are such as to allow the normal growth of crops. The first considerations in its management are protection against overflow and provision for drainage. Both of these call for cooperative action.

The acidity of this type varies, depending on location with reference to the hilly region in the southeastern part of the county. The tributaries flowing out of this hilly region, in which a few limestone outcrops occur, apparently carry sufficient lime in solution to affect the reaction of the bottoms subject to overflow by their waters. These bottom lands vary from slight to medium in acidity, while the bottoms which receive overflow from the glaciated region to the north vary from medium to strong in acidity.

After the overflow problem has been taken care of, it is suggested that limestone be applied in accordance with the need as shown by tests, and that clover be grown as a source of nitrogen and organic matter, in both of which this soil is deficient. No mineral fertilizer treatment is advised at present, except on a trial basis.

Mixed Loam (1354)

Mixed Loam has been mapped in the bottom lands of the smaller streams, principally in the unglaciated area of the county. This type of soil is variable as to texture and composition, is subject to frequent overflow, and often the surface material is changed after a heavy rain. The type occupies 11.59 square miles.

Mixed Loam is the youngest soil in the county and has no true profile development. The surface soil is usually yellow in color. It is mostly silt but contains some coarse and fine sand. At about 20 inches the yellow color changes to gray and very seldom is there much sand present. Mixed Loam is usually well drained.

Management.—This type varies in degree of acidity. It is a productive soil, easily farmed because of its sand content, and should be managed in the same way as suggested for Deep Gray Silt Loam, Bottom.

Drab Clay Loam (1321)

Drab Clay Loam occupies the low, flat, and swampy land in the preglacial valleys, covering an area of 30.17 square miles. It overflows each year, the water forming shallow ponds which do not dry up until summer. It is an alluvial soil formed thru the deposition of the finer particles in back water or in water without current.

The surface soil to a depth of 4 to 6 inches is a plastic, black or dark drab clay loam. Often an inch or so of silt is found on the surface, owing to a recent deposit. Below this to a depth of 18 to 20 inches a heavy, plastic, grayish drab clay is found. Below 20 inches the soil changes to a very plastic, grayish yellow clay.

Management.—Drab Clay Loam is usually not acid, owing to frequent overflow. It is productive, but because of its heavy texture is not so easily farmed as the two preceding types. Tile, if installed, should probably be put not over 4 rods apart and 30 inches deep; thus installed, they would eliminate the open ditches which are now used to remove excess water. It is particularly important to maintain a good supply of fresh organic matter in this soil, as it tends easily to get into poor physical condition. The best utilization of this land requires that it be protected from flood water. After this protection has been afforded, then the nitrogen and organic matter needs of the soil may be met by growing clover at regular intervals, limestone may be applied as it becomes necessary, and tile may be installed as time and other considerations permit.

Yellow-Gray Silt Loam On Clay (1334.1)

Yellow-Gray Silt Loam On Clay occupies an area about a mile wide along each side of the two main tributaries of Saline river, and is found in smaller areas near Rector creek. The soil is of alluvial formation, slightly higher than the surrounding land, and not subject to such frequent overflow as Mixed Loam and Drab Clay Loam. Water never remains on this type for any length of time, and very seldom is there any deposit left. The land has been heavily covered with timber, chiefly oak, for many years. This type covers an area of 16.21 square miles.

The A_1 horizon, or surface soil, 0 to 4 inches, is a friable silt loam, brownish gray or yellowish brown as the type approaches Brown Silt Loam On Clay or Drab Clay Loam, and yellowish gray on the tops of the low ridges and near the stream channels. The A_2 horizon, or subsurface soil, 4 to 16 inches, is a slightly compact, yellowish gray clayey silt loam. The B horizon, or subsoil below 16 inches, is a very compact, plastic, yellow clay.

Management.—Yellow-Gray Silt Loam On Clay varies considerably in productive capacity depending on its topographic position. The flat areas have a more impervious subsoil than the undulating areas and are less productive. This type is strongly acid and is low in nitrogen and organic matter. Three to four tons of limestone per acre should be applied, and clover grown at frequent intervals. After this has been done, trial should be made of one or more of the phosphates with particular reference to wheat, and it would also be well to try one of the potash salts for corn applied at the rate of about 100 pounds an acre.

Brown Silt Loam On Clay (1326.1)

Brown Silt Loam On Clay, when properly drained and cared for, is the most fertile land in the county. It is found chiefly along Rector creek in Plainview township (Township 7 South, Range 7 East). Smaller areas occur as slight knolls in the large areas of Drab Clay Loam. It covers 8.96 square miles.

The A_1 horizon, or surface soil, 0 to 8 inches, is a friable, grayish brown to black, heavy silt loam. The A_2 horizon, or subsurface soil, 8 to 16 inches, is a slightly compact, plastic, silty clay loam. The B horizon, or subsoil, 16 to 24 inches, is a compact, plastic, brownish yellow clay. The C horizon, or lower subsoil, below 24 inches, is a compact, plastic, yellow clay.

Management.—Brown Silt Loam On Clay usually is not acid, and is fairly well supplied with organic matter. Clover, as a source of nitrogen and fresh organic matter, should be grown at frequent intervals. If this is done, it is questionable whether any fertilizing materials can be used at the present time at a profit, excepting, of course, farm manure, which should always be carefully conserved and returned to the land.

RESIDUAL SOILS

Residual soils are confined entirely to the unglaciated region. They are of little agricultural value as they cannot be cropped with any success. Their topography is extremely rough and they can, no doubt, be most economically utilized by growing timber. Some areas may be used as pasture, and where limestone is the outcropping rock, it may serve as a source of material to sweeten sour or acid soil. This group of soils covers an area of 13.02 square miles.

Stony Loam (098)

Stony Loam occupies the steep slopes and gullies where erosion has removed most or all of the loess and residual soil material. The stones vary from a few inches to several feet in diameter and lie thick on the ground. This soil type comprizes 12.45 square miles. It is of little agricultural value, its only use, aside from the growing of timber, being for pasture.

Rock Outcrop (099)

Rock Outcrop is not considered a type of soil, for it is merely the exposure of rocks on the surface. These rocks occur most often as perpendicular ledges, the horizontal width of which is often exaggerated on the soil map in order to show the boundary lines. The outcrops are chiefly sandstone; limestone is exposed in deep ravines and at the base of bluffs but is always capped by sand stone. This limestone may be crushed, ground, and used to correct the acidity of sour soils.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

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

The 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 which may assist in the differentiation of types, but which are not fundamental to it, are native vegetation (whether timber or prairie), topography, and geological origin and formation.

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 as determining soil types.

Geological Origin. Geological origin involves the idea of character of rock materials composing the soil as well as the method of formation of the soil 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 four or more horizons and it is impossible to describe each horizon in the type name. The color and texture of the surface soil are usually included in the type name and when material such as sand, gravel, or rock lies at a depth of less than 30 inches, the fact is indicated by the word "on," and when its depth exceeds 30 inches, by the word "over"; for example, Brown Silt Loam On Gravel, and Brown Silt Loam Over Gravel.

As a further step in systematizing the 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,* covering nearly the south third of the state
400 *Middle Illinoisan glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoisan glaciation,* covering about fourteen counties northwest of the middle Illinoisan glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoisan
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois, and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation
1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation

1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* found in the older or Illinoisan glaciation
1400 *Late river-bottom and swamp lands,* those of the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

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 7.

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,*

TABLE 5.—PLANT-FOOD ELEMENTS IN COMMON FARM CROPS[1]

Produce		Nitrogen	Phos-phorus	Sulfur	Potas-sium	Magne-sium	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.

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 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 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.

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's growth ready to plow under as green manure.
[3]Wood ashes also contain about 1.000 pounds of lime (calcium carbonate) per ton.

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 420 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor 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 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.

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.

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.

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.

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[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 similar preparations which are satisfactory.

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 nitrogenous and fatty matter from the bones, thus producing a more nearly pure form of calcium phosphate containing about 10 to 12 percent of the element phosphorus.

Acid phosphate is produced by treating rock phosphate with sulfuric acid. The two are mixed in about equal amounts; the product therefore contains about one-half as much phosphorus as the rock phosphate itself. 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 positive value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of the state) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

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

Sulfur exists in the soil in both organic and inorganic forms, the former being gradually converted to the latter form thru bacterial action. In this inorganic form sulfur is taken up by plants which in their physiological processes change it once more into an organic form as a constituent of protein.

When these plant proteins are consumed by animals, the sulfur becomes a part of the animal protein. When these plant and animal proteins are decomposed, either thru bacterial action, or thru combustion, as in the burning of coal, the sulfur passes into the atmosphere or into the soil solution in the form of sulfur dioxid gas. This gas unites with oxygen and water to form sulfuric acid, which is readily washed back into the soil by the rain, thus completing the cycle, from soil—to plants and animals—to air—to soil.

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

Four-Year Rotations

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

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

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

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

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

Three-Year Rotations

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

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

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

Two-Year Rotations

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

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

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

SUPPLEMENT: EXPERIMENT FIELD DATA

(Results from Experiment Fields on Soil Types Similar to Those Occurring in Saline 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 is the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system.

Crop Rotations

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

Soil Treatment

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

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

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

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

Mineral Manures.—The yearly acre-rates of application have been: for limestone, 1,000 pounds; for raw rock phosphate, 500 pounds; and for potassium, 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 = Legumes used as green manure
( ) = Parentheses enclosing figures signify tons of hay, as distinguished from bushels of seed

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

THE RALEIGH FIELD

A University soil experiment field is located in Saline county immediately south of Raleigh. This field has been in operation since 1910. It comprizes 14 acres of light-colored, loessial soils characteristic of the region. The soil type indicated on the county map is Yellow-Gray Silt Loam. With accumulating experience in the soil survey, however, certain soil characteristics have come

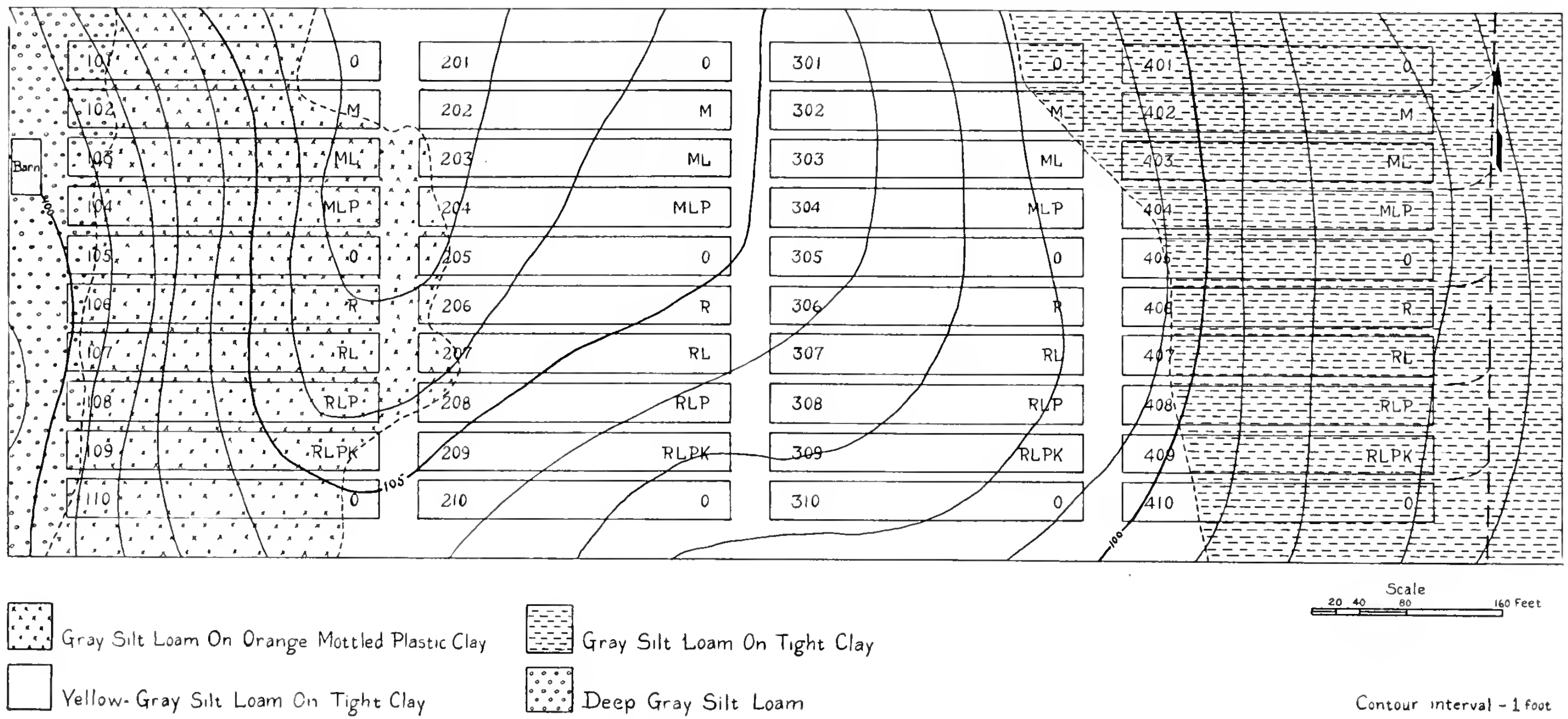

FIG. 2.—DIAGRAM OF THE RALEIGH SOIL EXPERIMENT FIELD

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.

TABLE 7.—RALEIGH FIELD: 1910–1923

Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1910 Wheat[1]	1911 Corn	1912 Oats	1913 Clover	1914 Wheat	1915 Corn	1916 Oats	1917 Soybeans	1918 Wheat	1919 Corn	1920 Oats	1921 Clover	1922 Wheat	1923 Corn
101	0..........	9.5	28.0	11.9	(.22)	11.8	21.4	10.8	(.76)	10.2	18.2	4.1	(.12)	8.0	23.9
102	M..........	6.9	41.0	15.2	(.23)	10.9	35.1	11.2	(.84)	14.6	29.4	3.9	(.52)	9.5	47.5
103	ML.........	9.8	45.8	23.4	(.72)	27.5	57.2	12.0	(1.25)	25.9	35.0	5.2	(1.69)	15.3	67.0
104	MLrP.......	11.6	46.7	22.7	(.68)	26.8	52.3	14.7	(1.57)	29.2	44.4	5.3	(2.03)	17.5	65.8
105	0..........	7.3	24.9	14.1	.02	9.4	21.8	10.9	3.5	11.8	13.4	2.8	(.18)	6.3	27.1
106	R..........	9.0	24.4	12.8	.02	9.2	24.4	11.4	5.7	12.8	17.5	3.0	(.28)	9.9	31.2
107	RL.........	11.0	36.8	20.9	.08	25.1	43.5	10.6	10.4	22.2	40.0	8.0	(1.45)	20.6	53.9
108	RLrP.......	10.7	31.1	23.0	.01	27.2	42.0	14.7	12.9	27.2	48.0	7.7	(1.85)	18.5	59.7
109	RLrPK......	12.7	39.5	25.8	.03	30.0	47.2	16.7	9.4	24.9	50.1	7.9	(1.92)	29.6	68.2
110	0..........	5.7	17.8	8.1	.01	7.2	22.3	9.2	(.67)	10.7	17.0	1.7	(.07)	4.5	22.8
		Cowpeas[1]	Wheat[2]	Corn	Oats	Soybeans	Wheat[4]	Corn	Oats	Clover	Wheat	Corn	Oats	Soybeans	Wheat
201	0..........	(.86)	12.1	20.5	.6	(.28)	....	22.9	17.5	(.26)	5.8	11.4	8.3	3.4	.0
202	M..........	(.75)	12.7	36.5	2.0	(.30)	....	34.9	23.3	(.12)	10.9	26.4	7.3	4.3	.3
203	ML.........	(1.38)	17.5	55.1	3.1	(.26)	....	45.0	36.1	(.86)	23.5	56.9	15.8	8.7	2.9
204	MLrP.......	(1.35)	19.0	53.9	3.0	(.23)	....	43.2	36.7	(1.01)	24.1	60.7	15.2	9.3	3.9
205	0..........	(.74)	9.5	20.4	1.7	(.27)	....	23.6	20.3	.00	9.3	15.2	6.9	5.5	.0
206	R..........	....[3]	12.3	29.9	2.0	2.5	....	24.7	25.9	.00	12.6	22.6	12.7	5.7	.0
207	RL.........	....[3]	19.9	45.2	4.4	2.5	....	40.1	42.0	.21	21.7	42.8	17.8	11.1	2.0
208	RLrP.......	....[3]	22.7	55.1	5.2	2.7	....	45.6	44.8	.25	24.7	44.8	19.8	14.2	2.2
209	RLrPK......	....[3]	22.8	56.5	7.2	1.8	....	46.8	47.7	.33	26.3	59.7	17.7	18.3	3.9
210	0..........	(1.09)	14.7	25.2	2.7	.7	....	30.0	30.2	(.12)	14.2	23.9	7.3	8.5	.2

TABLE 7.—RALEIGH FIELD, *Concluded*

Plot No.	Soil treatment applied	1910 Oats[1]	1911 Clover[2]	1912 Wheat[2]	1913 Corn	1914 Oats	1915 Soybeans	1916 Wheat	1917 Corn	1918 Oats	1919 Soybeans	1920 Oats[6]	1921 Corn	1922 Oats	1923 Soybeans
301	0..........	18.1	(.44)	3.4	5.7	2.5	1.1	.8	24.4	26.2	(.24)	11.9	.6	2.2	6.9
302	M..........	17.3	(.43)	2.3	12.9	5.0	(1.81)	1.8	44.7	35.6	(.28)	15.5	6.3	2.8	11.0
303	ML.........	26.8	(.61)	7.1	17.2	8.1	(2.16)	7.8	57.5	47.5	(.64)	20.0	20.0	10.9	21.2
304	MLrP.......	26.0	(.68)	7.8	17.1	7.8	(2.30)	9.8	58.9	47.3	(.86)	18.6	28.6	10.8	23.6
305	0..........	15.0	(.23)	2.0	4.5	2.0	1.0	.2	25.7	24.1	2.2	10.0	7.3	1.1	9.2
306	R..........	20.9	....[3]	2.8	9.4	4.1	.8	.7	19.9	31.6	2.8	12.2	12.6	1.9	12.7
307	RL.........	25.1	....[3]	7.4	17.5	9.5	3.4	6.7	45.1	55.9	6.7	18.0	28.5	11.4	20.3
308	RLrP.......	25.1	....[3]	9.9	17.9	11.2	3.9	7.7	41.1	56.1	7.8	18.6	39.3	13.8	21.8
309	RLrPK......	29.3	....[3]	14.1	15.9	10.3	3.9	6.6	63.4	55.2	9.1	18.9	50.9	12.2	24.1
310	0..........	22.9	....[3]	4.7	7.4	5.0	.4	1.8	35.1	29.8	(.47)	13.4	26.4	3.0	13.6
		Corn[1]	Oats[2]	Cowpeas[2]	Wheat[2]	Corn	Oats	Clover	Wheat	Corn	Oats	Clover	Wheat	Corn	Oats
401	0..........	24.1	25.6	(1.44)	6.2	7.6	9.7	(.56)	6.3	13.2	9.2	(.00)	8.2	18.9	9.5
402	M..........	18.1	19.2	(1.05)	4.2	13.2	8.9	(.89)	7.8	22.9	9.1	(.00)	9.2	35.8	14.1
403	ML.........	40.1	38.0	(2.79)	20.7	16.3	23.6	(1.44)	41.2	22.9	20.8	(1.28)	25.8	66.6	28.0
404	MLrP.......	37.4	35.5	(2.56)	23.8	14.1	24.7	(1.98)	39.2	20.4	21.9	(1.60)	28.2	67.5	31.9
405	0..........	24.9	18.4	(.93)	6.4	8.5	9.8	....[5]	11.2	14.9	7.5	(.00)	9.2	23.2	12.8
406	R..........	31.1	24.1	....[3]	8.5	10.7	12.8	....[5]	15.2	17.8	11.9	(.00)	11.2	27.1	11.7
407	RL.........	42.8	38.6	....[3]	29.8	14.4	23.1	....[5]	37.2	23.8	22.8	(1.60)	25.3	46.5	29.5
408	RLrP.......	44.5	35.3	....[3]	32.9	16.4	22.5	....[5]	40.5	22.8	22.8	(1.61)	29.2	48.8	30.8
409	RLrPK......	43.0	32.8	....[3]	29.8	16.4	20.8	....[5]	46.4	23.7	25.0	(1.79)	32.5	57.2	30.6
410	0..........	26.8	25.0	(1.14)	4.7	4.6	7.5	(.83)	5.3	12.8	8.6	(.00)	9.0	20.6	13.4

[1]No manure or residues. [2]No manure. [3]No seed harvested. [4]Crop destroyed by hail. [5]Seed lost before recleaning. [6]Substitute for wheat.

to attention which formerly were not recognized and which, in some instances, call for modifying the classification shown by the county soil map. Thus a more detailed examination has revealed the presence of what now may be regarded as four distinguishable soil types on the Raleigh field; namely, Yellow-Gray Silt Loam On Tight Clay, Gray Silt Loam On Tight Clay, Gray Silt Loam On Orange-Mottled Plastic Clay, and Deep Gray Silt Loam. The distribution of these soil types as well as the arrangement of plots is charted on the accompanying diagram (Fig. 2). The topography, or lay of the land, is indicated on the diagram by contour lines. The land has been tiled and the drainage is good.

The field is laid out into four series of 10 plots each. Fortunately the plot series run fairly parallel with the soil types in such manner that the 100 Series is located mainly on Gray Silt Loam On Tight Clay, the 200 and 300 Series are almost entirely confined to Yellow-Gray Silt Loam On Tight Clay, and the 400 Series lies mainly on Gray Silt Loam On Orange-Mottled Plastic Clay. The plots are under a four-crop rotation system of wheat, corn, oats, and clover. In the event of clover failure either soybeans or cowpeas have been substituted as the legume crop. The soil treatments are as indicated in the accompanying diagram and tables, and until 1922 they were applied in the manner described above. In 1922 the return of the wheat straw in the residue system was discontinued. In the same year the regular application of limestone was suspended until such time as it appears to be needed again. In 1923 the rock phosphate was evened up on all phosphate plots to a total application of 4¼ tons an acre, and the applications were discontinued for an indefinite period.

At this time the plots were divided into west and east halves for the purpose of instituting some new investigations designed to help solve some of the problems that have arisen during the course of the experiments. The west halves were continued under their original treatments, while the east halves were given over to a study of the phosphate question. The particular treatments on the divided plots are shown in Table 8.

The yields of all the crops grown since the beginning of the experiments are placed on record in Tables 7 and 8. For convenience in studying the effects of the treatments, the results are summarized and presented in Table 9, which shows the average annual yields for the several kinds of crops, including the years since the complete plot treatments have been in effect. This summary includes all of the results of Table 7, together with those in Table 8, which pertain to the west half-plots.

A study of these data brings out the following comments concerning the effects of the various treatments on the Raleigh field:

1. The untreated plots are conspicuous in their low yields.

2. All the different kinds of crops show some response to the application of stable manure, altho the beneficial effect varies greatly.

3. Crop residues used alone have been of very little effect.

4. Limestone stands out in its effect as the most prominent agency in soil improvement.

5. The combination of residues and limestone has produced yields almost as high as that of manure and limestone.

FIG. 3.—CORN ON THE RALEIGH FIELD

At the right no treatment has been applied; at the left, manure, limestone, and phosphate have been applied, the major effect being produced by the limestone and manure.

FIG. 4.—CORN ON THE RALEIGH FIELD

The treatment here is the same as that shown in Fig. 3 except that no manure is used, the organic matter being supplied by crop residues, including stalks, straw, and legumes plowed under.

TABLE 8.—RALEIGH FIELD: 1924-1925
Annual Crop Yields—Bushels or (tons) per acre

Serial plot No.	Soil treatment	1924 Series 100 Oats	1924 Series 200 Corn	1924 Series 300 Wheat	1924 Series 400 Clover	1925 Series 100 Timothy-clover	1925 Series 200 Oats	1925 Series 300 Corn	1925 Series 400 Wheat
1 W	0	16.6	1.2	.3	(0.00)	(0.00)	12.8	17.4	1.8
1 E	RL	18.8	1.4	1.2	(0.00)	(0.00)	17.5	22.0	6.3
2 W	M	32.8	7.8	3.2	(0.00)	(.44)	25.9	29.0	7.3
2 E	MrP	35.6	.6	7.5	(0.00)	(.29)	35.9	31.6	10.5
3 W	ML	50.3	33.2	10.7	(1.31)	(2.24)	44.7	33.2	25.5
3 E	MLbP	50.6	26.8	13.5	(1.64)	(1.80)	46.9	44.0	33.7
4 W	MLrP[1]	57.5	34.4	15.8	(1.42)	(2.37)	46.9	37.0	26.7
4 E	MLrP	50.9	27.6	17.3	(1.78)	(2.09)	49.7	44.8	34.3
5 W	0	29.1	2.2	0.0	(0.00)	(.41)	17.5	11.8	3.5
5 E	RaP	28.1	.1	5.3	(0.00)	(0.00)	27.8	16.2	13.8
6 W	R	29.1	6.0	1.2	(0.00)	(.32)	22.5	20.0	5.8
6 E	RrP	26.6	2.0	6.3	(0.00)	(0.00)	34.7	24.2	17.7
7 W	RL	47.8	33.0	7.3	(1.41)	(1.00)	32.2	37.2	22.0
7 E	RLaP	54.1	38.2	14.0	(.28)	(.99)	43.8	38.6	28.5
8 W	RLrP[1]	58.1	32.2	9.2	(.57)	(1.68)	43.0	54.0	26.7
8 E	RLrP	50.3	45.6	11.2	(.87)	(1.37)	45.9	54.2	31.8
9 W	RLrP[1]K	57.2	41.4	14.0	(1.25)	(1.98)	42.5	52.8	28.2
9 E	RLrP[1]K-Gypsum	50.9	45.2	18.3	(1.47)	(1.70)	48.8	60.4	34.7
10 W	0	16.6	2.6	1.5	(0.00)	(0.00)	15.6	24.4	9.2
10 E	RLrP	17.5	13.2	4.2	(0.00)	(0.00)	44.7	46.8	12.7

[1]Residual phosphate.

6. A very small crop increase in every case has attended the application of phosphate, but this increase is not sufficient to cover the cost of the rock phosphate used. As mentioned above, the phosphate problem is now being

TABLE 9.—RALEIGH FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1911-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *15 crops*	Oats *15 crops*	Wheat *10 crops*	Clover[1] *7 crops*	Soybeans[1] *6 crops*
1	0	15.7	10.3	5.3	(.17)	(.61)
2	M	28.2	14.2	7.6	(.31)	(.80)
3	ML	41.9	23.3	20.6	(1.36)	(1.22)
4	MLrP	43.0	24.3	22.1	(1.58)	(1.38)
5	0	16.3	11.4	6.1	(.10)	(.40)
6	R	19.9	13.7	7.9	(.10)	(.50)
7	RL	36.6	23.6	19.0	(.96)	(.91)
8	RLrP	39.9	25.9	21.3	(1.00)	(1.06)
9	RLrPK	46.0	26.4	24.2	(1.22)	(1.11)
10	0	19.5	11.5	6.4	(.15)	(.65)

[1]Including several seed crops evaluated in this summary as hay.

made the subject of special investigation on these plots. The residual effect of phosphate previously applied, on the one hand, and new applications under different methods, on the other hand, should furnish in the next few years much more definite information regarding the economical use of phosphate than now exists.

7. Potassium in the form of kainit has likewise increased the yield of all crops, particularly the corn, wheat, and clover. At current prices the value of the increase is just about offset by the cost of the kainit applied.

FIG. 5.—A PARTY LOOKING OVER DEMONSTRATIONS IN SOIL MANAGEMENT ON THE RALEIGH EXPERIMENT FIELD

Regarding the cropping system employed on this field, it may be said that altho it serves fairly well for experimental purposes in determining the needs of the soil, for farming practice it doubtless could be improved, either by substituting a more profitable crop for the oats, or by rearranging the crop sequence and omitting the oats.

THE SPARTA FIELD

As representative of experimental results on the soil type Light Gray Silt Loam On Tight Clay, data from certain plots on the Sparta experiment field are introduced here. The Sparta field was established in Randolph county immediately north of the town of Sparta in 1916. The four series of plots designated as the 100, 200, 300, and 400 Series, with the exception of parts of two plots, are all on the soil type mapped as Light Gray Silt Loam On Tight Clay. They are under a crop rotation of corn, soybeans, wheat, and clover (chiefly sweet clover). Until 1921 is was the practice to seed cowpeas as a cover crop in the corn on the residues plots. The soil treatments are as indicated in the accompanying table, and they have been applied in the manner previously described, with the exception that the initial application of limestone was 5 tons an acre and in 1922 the periodic application of this material was discontinued until its further need should become apparent.

Table 10 gives a summary of the results showing the average annual yields for the different kinds of crops, including the years that the complete soil treatments have been in effect.

The low yields on the untreated plots testify to the natural poverty of this soil, altho this particular piece of land, on account of its favorable location with

TABLE 10.—SPARTA FIELD: SERIES 100, 200, 300, AND 400
SUMMARY OF CROP YIELDS
Average Annual Yields 1917-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *9 crops*	Soybeans[1] *8 crops*	Wheat *7 crops*	Clover *1 crop*	Sweet clover seed *5 crops*
1	0	15.6	(.62)	5.4	(0.00)	0.00
2	M	19.4	(.80)	7.8	(0.00)	0.00
3	ML	29.8	(1.47)	17.1	(1.66)	1.60
4	MLrP	30.8	(1.47)	17.7	(1.73)	1.38
5	0	13.4	(.52)	5.5	(0.00)	0.00
6	R	16.3	(.61)	5.5	(0.00)	0.00
7	RL	23.3	(1.28)	16.2	(1.50)	1.17
8	RLrP	23.4	(1.38)	17.1	(1.87)	1.41
9	RLrPK	29.2	(1.40)	18.3	(1.69)	1.86
10	0	11.4	(.59)	4.6	(0.00)	0.00

[1]Including several seed crops evaluated in this summary as hay.

respect to drainage, is rather more productive than the general run of the type that it represents.

Neither manure nor residues, used alone, has much effect toward crop improvement. A sharp increase, however, follows the application of limestone used with either manure or residues. Without limestone, clover refuses to grow; with limestone, fair crops of clover have been obtained. Rock phosphate in addition to limestone has produced no significant effect, used either with manure or with residues.

Potassium seems to have been of some benefit to the corn but not to the other crops. It is questionable, however, whether the increase in corn yield would cover the cost of material as it was used in these experiments. It is possible that smaller quantities applied direct to the corn crop would prove a more economical way to use potassium fertilizer on this soil.

THE ELIZABETHTOWN FIELD

The Elizabethtown experiment field was established by the University in 1917, in the unglaciated hilly section of southern Illinois. This field is located in Hardin County about two miles north of Elizabethtown. The soil is of loessial formation, the predominating type on this field being classified as Yellow Silt Loam. A detailed examination, however, shows the presence of some Yellow-Gray Silt Loam and also a very small patch of Stony Loam. The land is extremely rough in topography, the contour map showing a range in elevation of 42 feet on that part of the field occupied by the present plots. Erosion, therefore, is a serious problem. The field embraces about 32 acres, of which area about one-half is laid off into plots. There are four series of 10 fifth-acre plots each, included in a major rotation. Another series of 10 tenth-acre plots is devoted to another rotation, and in addition to these there are three other plots designated as A, B, and C, upon which a special phosphate test is being carried on.

The major rotation formerly included corn (with rye cover crop), soybeans, wheat, and sweet clover, but this was changed in 1923 to a rotation of corn, wheat, clover-timothy mixture, and wheat with sweet clover seeding on the residue plots. The plot treatments are indicated in the following table of

TABLE 11.—ELIZABETHTOWN FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1919-1925—Bushels or (tons) per acre

Serial plot No.	Soil treatment	Corn *7 crops*	Wheat following legume *5 crops*	Wheat following corn *3 crops*	Timothy-clover mixture *3 crops*	Soybeans *3 crops*	Sweet clover seed *2 crops*
1	0	18.6	7.8	4.9	(.12)	2.7	0.00
2	M	18.3	6.2	4.6	(.10)	3.1	0.00
3	ML	33.3	14.0	9.3	(.94)	4.2	2.59
4	MLrP	40.6	18.2	9.7	(1.37)	5.2	2.42
5	0	12.9	5.8	2.0	(.07)	2.3	0.00
6	R	15.9	5.1	2.3	(.09)	2.5	0.00
7	RL	34.8	12.2	5.7	(.94)	4.3	1.99
8	RLrP	45.2	17.6	8.1	(1.37)	5.0	1.74
9	RLrPK	44.8	19.3	8.3	(1.65)	4.6	1.49
10	0	23.6	7.7	4.8	(.05)	3.0	0.00

results. The difficulty of obtaining satisfactory experimental data on land of such rough topography is obvious. There are, however, certain effects standing out in such bold relief as to leave no doubt as to their significance. The results for the different crops are summarized in Table 11.

These results show extremely poor yields on the untreated land, with no improvement from the use of manure alone or residues alone. A sharp increase in yield, however, follows the application of limestone along with either manure or residues. Rock phosphate seems to have produced a beneficial effect on the corn, on the wheat following legumes, and on the timothy-clover mixture, in both the manure and the residues systems. The potassium treatment as applied in these experiments does not show sufficient benefit to cover the cost. The following general observations are of interest. The wheat following legumes has a much more favorable place in the rotation than the wheat following corn, which fact is manifested by the relative yields. Soybeans have not proved a very successful crop on this field. It is of interest to note that the residues system appears to be fully as effective in building up this soil as the manure system, but a rational system of farming might well include livestock, in which the manure as well as all available crop residues would be utilized for soil improvement.

The results from the minor rotation on Series 500 are too few to warrant consideration at this time.

On Plots A, B, and C a comparison of the two carriers of phosphates, acid phosphate and rock phosphate, is under way. The acid phosphate is applied at the rate of 200 pounds an acre a year and the rock phosphate in double this quantity. The plots also receive residues and limestone.

In a rotation of corn, cowpeas, and wheat, four crops of corn, three of cowpeas, and three of wheat can be compared at this time. It is of interest to note the results that thus far have been obtained, bearing in mind that the data are not sufficient to warrant drawing final conclusions as to which carrier of phosphorus will prove to be the more economical to use. Table 12 presents the crop yields from these comparative phosphate tests covering the period since the full soil treatment has been applied.

TABLE 12.—ELIZABETHTOWN FIELD: COMPARATIVE TEST OF ACID PHOSPHATE AND ROCK PHOSPHATE

Annual Yields of Crops Grown, 1921-1925—Bushels or (tons) per acre

Year	Corn		Wheat		Cowpeas	
	Acid phosphate	Rock phosphate	Acid phosphate	Rock phosphate	Acid phosphate	Rock phosphate
1921.......	28.8	28.6	....	....	9.2	7.8
1922.......	34.4	32.0	3.2	9.8	12.5	4.7
1923.......	32.2	46.8	18.6	14.3	10.5	9.2
1924.......	54.6	59.2	13.3	8.8	(.78)	(.80)
1925.......	60.2	62.0	8.5	10.0	(1.66)	(1.27)
Average...	42.0	45.7	12.4	11.9	Seed 10.7 Hay (1.22)	7.2 (1.04)

On the whole, the differences shown in the averages are relatively small, so that it may be said that after four years the data furnish no reliable indication as to which form of phosphate is the more effective in increasing crop yields.

THE OLD VIENNA FIELD

From 1902 to 1911 the University conducted an experiment field in Johnson county, about two miles southeast of Vienna, on land that was described at the time as "red clay, a soil typical of the hill sections of the state." The soil is characteristic of much of the type designated as Yellow Silt Loam. The field comprized a tract of 5.6 acres of land rolling in topography, a portion of which was low and wet. It was not tile-drained.

Previous to 1902 this land had been cultivated for about fifty years, after which it was said to be still capable of producing fair crops of corn and wheat.

For the experiment work the field was laid out into three series of plots one-fifth acre in size, each series containing 5 plots. A crop rotation of wheat, corn, and cowpeas was started; but in 1905 this rotation was changed to corn, oats, wheat, and legumes. Cowpeas for plowing down were seeded in the corn at the last cultivation excepting on Plot 1. As the carrier of phosphorus, steamed

TABLE 13.—OLD VIENNA FIELD: SUMMARY OF GRAIN CROPS

Average Annual Yields 1903-1911—Bushels per acre

Soil treatment	Corn *9 crops*	Wheat *8 crops*
0...............................	29.0	3.0
Le..............................	29.8	5.7
LeL.............................	39.7	10.9
LeLP............................	37.5	13.6
LeLPK...........................	40.7	15.6

bone meal was used at the rate of 200 pounds an acre a year. Potassium was applied in the form of potassium sulfate, this material being used at the annual acre rate of 100 pounds. Lime was applied in 1902 in the form of slaked lime at the rate of 1,800 pounds, and the following year limestone was added at the rate of 8 tons an acre.

Table 13 presents a summary giving the average annual acre yields of the 9 corn crops and 8 wheat crops harvested after the plots had received their respective treatments.

The great need of this land for organic matter and nitrogen is brought out in these results. Organic matter and nitrogen are furnished by the legumes in these experiments; but in order to produce a thrifty growth of legumes, it was necessary to apply lime. Thus, upon the addition of limestone, the corn yield was increased by one-third, while the wheat yield was practically doubled. In the case of the corn, little or no effect was produced by the addition of either phosphorus or potassium treatment. In the wheat, however, an increase of about 3 bushels an acre a year appears upon the addition of phosphorus, and a further increase of 2 bushels an acre a year upon including potassium in the treatment.

The yields from the three clover crops are not summarized here but it may be stated that some very fair yields of clover were obtained on the better treated plots.

Altho these results furnish an indication of the most important needs of this land, it cannot be said that the experiments as conducted represent directly an economical system of farming. Considering the several years in which the land was given over to the growth of a green manure crop when nothing was harvested, even the yields from the best plots would scarcely be sufficient to cover the cost of maintenance. However, it appears possible that by modifying the cropping plan in some manner, as for example, substituting sweet clover for cowpeas and giving large place in the farming system to hay and pasture crops, production might be substantially increased and thus a system of farming instituted that would represent a profitable enterprise.

THE NEW VIENNA FIELD

From 1906 to 1924 another experiment field, designated as the new Vienna field, was maintained. This field was located about a mile southeast of Vienna and about a half-mile west of the old Vienna field described above. It embraced 16 acres of the badly eroded, hilly land characteristic of the region.

The soil of this field is, in general, of loessial formation. It is strongly acid in reaction. A detailed examination of the area occupied by the field reveals three separable types, namely, Yellow Silt Loam, Yellow-Gray Silt Loam, and Deep Gray Silt Loam.

The work on this field from 1906 to 1915 was concerned with an investigation of methods of reclaiming this land primarily thru means of reducing erosion. Before taking over the field, the land, with the exception of about three acres, had been abandoned because so much of the surface soil had been washed away, and gulleying had become so bad that further cultivation was unprofitable. Some of the gulleys were four or five feet deep, so that the first step in reclaiming the land was to fill them and thus make the slopes more uniform.

The field was divided into five sections. The sections designated as A, B, and C were divided into 4 plots each, and D into 3 plots. On Section A, which included the steepest part of the area and contained many gullies, the land was

FIG. 6.—THIS UNIMPROVED HILLSIDE OCCURS OVER THE FENCE FROM THE FIELD SHOWN IN FIG. 7

built up into terraces at vertical intervals of five 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 if the water breaks over, it will run over in a broad sheet rather than in rills thru 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 exceptions, about eight loads of manure an 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.

TABLE 14.—NEW 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)

FIG. 7.—CORN GROWING ON IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD. THIS LAND FORMERLY HAD BEEN ERODED (Compare with Fig. 6)

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 were not entirely uniform; some parts were washed more than others and portions of the lower-lying land had been affected by soil 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 excepting D which had but three plots.

Table 14 contains a summarized statement of the results obtained. For a more detailed account of this work the reader is referred to Bulletin 207 of this Station entitled "Washing of Soils and Methods of Prevention."

These results indicate something of the possibilities in improving hillside land by protecting it from erosion. The average yield of corn 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. 6 and 7 will serve to indicate the possibility of improving this type of soil.

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