[redacted]

MACON COUNTY SOILS

45

Copy

UNIVERSITY OF ILLINOIS
Agricultural Experiment Station

SOIL REPORT No. 45

MACON COUNTY SOILS

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

URBANA, ILLINOIS, DECEMBER, 1929

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.

STATE ADVISORY COMMITTEE ON SOIL INVESTIGATIONS
1929-1930

F. I. Mann, Gilman
G. F. Tullock, Rockford
N. F. Goodwin, Palestine
W. E. Riegel, Tolono
F. S. Haines, Geneseo

RESEARCH AND TEACHING STAFF IN SOILS
1929-1930

Herbert W. Mumford, Director of the Experiment Station
W. L. Burlison, Head of Agronomy Department

Soil Physics and Mapping
R. S. Smith, Chief
O. I. Ellis, Assistant Chief
D. C. Wimer, Assistant Chief
E. A. Norton, Assistant Chief
M. B. Harland, Associate
R. S. Stauffer, Associate
D. C. Maxwell, Assistant
Eric Winters, Jr., Assistant
Herman Wascher, Assistant

Soil Fertility and Analysis
E. E. DeTurk, Chief
F. H. Crane, Associate
R. H. Bray, Associate
J. C. Anderson, First Assistant
F. M. Willhite, First Assistant
L. K. Eby, Assistant
E. B. Earley, Assistant

Soil Experiment Fields
F. C. Bauer, Chief[1]
H. J. Snider, Assistant Chief
C. J. Badger, Associate
A. L. Lang, Associate
A. U. Thor, First Assistant
L. B. Miller, Assistant
F. E. Schlots, Assistant
C. H. Farnham, Assistant
Allan Kirkwood, Assistant

Soil Biology
O. H. Sears, Assistant Chief
W. D. Gifford, Assistant
M. L. Hershberger, Assistant

Soils Extension
F. C. Bauer, Professor[1]
C. M. Linsley, Assistant Professor

Soil Survey Publications
L. H. Smith, Chief
F. W. Gault, Scientific Assistant
Nellie Boucher Smith, Editorial Assistant

[1]Engaged in Soils Extension as well as in Soil Experiment Fields.

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 Macon county was conducted, and Mr. F. W. Wascher, who, as leader of the field party, was in direct charge of the mapping.

CONTENTS

APPENDIX

SUPPLEMENT

MACON COUNTY SOILS

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

HISTORICAL REVIEW

Macon county is located near the center of Illinois. It is rectangular in shape, 27 miles north and south by about 21 miles east and west, and comprizes 581 square miles. The population in 1920 was 65,175, about one-third of which was rural. Decatur is the principal town and the county seat.

Much of the prairie was originally swampy and poorly drained, but since the establishment of artificial drainage, the excess surface water is quickly removed and the land is generally well drained. The surface of the county is a gently rolling plain broken by narrow belts of more rolling to slightly hilly country bordering the major stream valleys. Decatur lake, some 13 miles long and covering 5½ square miles, which was formed by confining water in the Sangamon river bottom land, is a recreational center for the community and furnishes the city of Decatur with an adequate water supply.

Macon county lies near the southern border of the fertile corn-belt section of the United States. Its soils are generally dark-colored, rich, and highly productive. The rainfall, temperature, and growing season are favorable for the growth of a wide variety of crops. Markets are close at hand and railroad transportation, both steam and electric, is so well developed that no farm in the county is more than seven miles from a shipping center. Recently built concrete roads, more than sixty miles of which radiate in all directions from the county seat, are playing an important role in further development. The dirt roads are well kept and are good except during the rainy seasons. Many of them are coated with oil annually and these seldom break up. The combination of all of these favorable factors has produced a highly developed agriculture thruout the county. Farm buildings and equipment indicate general prosperity. Educational facilities and social life are of the highest type of rural development.

The first white man to come into the area now included in Macon county was Joseph Stevens. He established the first community on the north bank of Sangamon river near the present site of the city of Decatur early in the nineteenth century. Most of the early settlers were natives of Kentucky, Tennessee, and North Carolina. Following 1820 the population grew rapidly as people came in from Ohio, Pennsylvania, and other eastern states. The more rolling parts of the county were settled first, and as fast as the land was drained, the entire area became populated. The region was originally part of Shelby county, but the present definite boundaries were made in 1829, when Macon county was created by an act of the Legislature. The first railroad to be constructed in the county was completed in 1852. A rapid expansion in both industry and agriculture followed.

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

AGRICULTURAL PRODUCTION

Early agriculture in Macon county was confined to raising enough food to meet the needs of home consumption. Vegetables, fruits, hay, and cereals were the chief crops. Livestock was raised, fattened, and driven overland to St. Louis to market. Much of the land remained in grass which served as pasture or was cut for hay. Surplus grain crops were not grown in the early days because of the lack of a market. Following the completion of railroad connections out of Springfield in 1842, some grain was hauled from Macon county and marketed there. According to early reports, wheat sold for 28 to 35 cents a bushel, but corn did not usually bring enough to pay for hauling it any distance. For the same reason very little oats, rye, or barley was grown. Expansion in agriculture was limited by the lack of transportation in this early period. It was natural, then, that following the completion of the first railroad in 1852, agriculture progressed rapidly. Attention was first given to draining the flat prairie land and increasing crop acreage. The area in farms increased from 30,000 acres in 1850 to more than 200,000 acres in 1870, and by 1880 there were nearly 340,000 acres in farms. Shortly after this, all the available farming area in the county was being utilized. The number of farms increased from 360 in 1850 to 2,872 in 1880, but thereafter there was a gradual decline to 2,441 in 1925. This decline in the number of farms has been attended by an increase in the acreage per farm. In 1880 the average size of farms was 127 acres, while in 1925 it was 142 acres.

The increase in the value of farms during the period from 1850 to the present gives an indication of the rapid development that has taken place in the agriculture of the county. In 1850 the value of farms, including buildings and equipment, was slightly less than one million dollars. Values increased 4 to 6 million dollars every decade from 1850 to 1900, when they jumped from 27½ to 67½ million dollars. During the World War period, when the average selling price of land was more than $300 an acre and some farms sold for more than $400 an acre, the value of farm property increased to more than 120 million dollars but has since declined to about 75 million.

The rapid increase in the area under cultivation is indicated by Fig. 1, which shows the acreage in corn, oats, and wheat in certain years during the period from 1850 to the present. The corn acreage expanded very rapidly for the first thirty years and reached a peak about 1900, when nearly one-half of the farm acreage in the county was in corn. Fig. 1 shows the acreage of wheat surpassing that of oats in the early period but declining after 1880. The increase in wheat acreage in 1920 was the result of war stimulation. The acreage seemed to regain normalcy by 1922. The total acreage in corn, oats, and wheat in 1928 was about 8 percent less than the average from 1900 to 1920. This does not mean a falling off in total crop production but rather that more of the acreage is being utilized for legumes and other crops.

The principal crops grown in Macon county are those common to the corn belt. The following data, taken from the United States Census of Agriculture made in 1925, gives the acreage, production, and yield per acre of the common crops for 1924.

Crops	*Acreage*	*Production*	*Yield per acre*
Corn, total acreage	143,139	......	......
Harvested for grain	139,219	5,593,349 bu.	40.2 bu.
Cut for silage	636	5,414 tons	8.5 tons
Cut for fodder	1,917	......	......
Hogged off	1,367	......	......
Wheat	35,250	571,954 bu.	16.2 bu.
Oats, threshed for grain	48,361	2,041,972 bu.	42.2 bu.
Oats, cut and fed unthreshed	634	......	......
Hay of all kinds	30,343	36,091 tons	1.19 tons
Timothy	5,215	......	......
Timothy and clover mixed	4,442	......	......
Clover	13,564	......	......
Alfalfa	1,664	......	......
Sweet clover	1,243	......	......

These census figures are for but a single year, and they will fluctuate from season to season, depending largely on climatic conditions. For that reason, the average yield over a period of years more nearly represents the conditions. For the past ten-year period, the U. S. Department of Agriculture gives the average yield of corn as 37.6 bushels; oats, 31.6 bushels; wheat, 18.8 bushels; hay, 1.4 tons.

The trend of yields per acre of the common crops in Macon county has been slightly upward since 1900. The average yield of corn for the ten-year period ending in 1899 was about 30 bushels per acre. The past ten-year period shows a 25 percent increase over this figure. The increase for wheat during the same

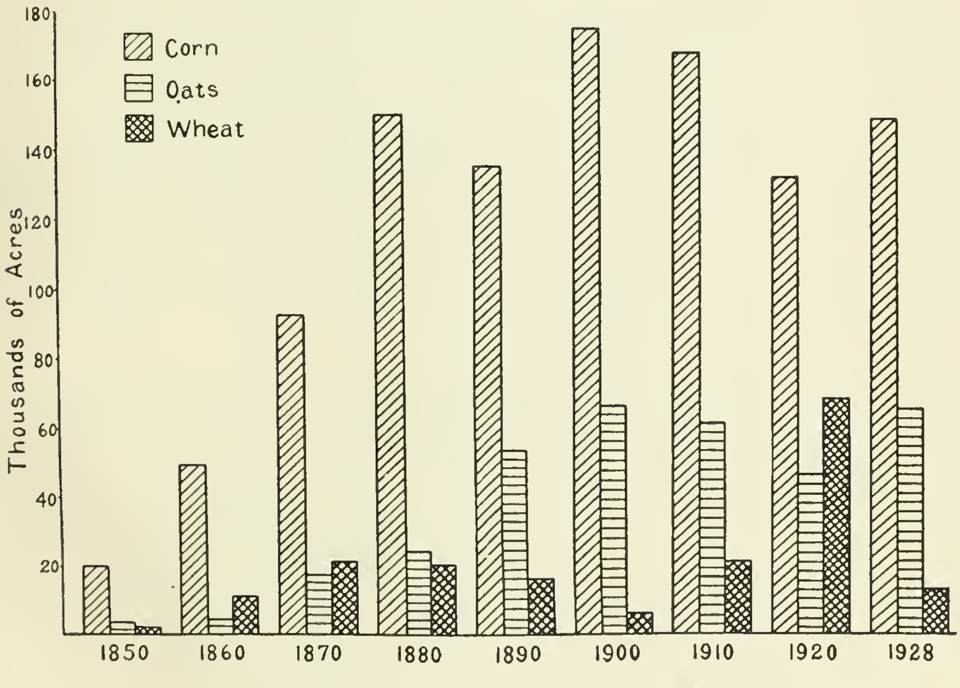


FIG. 1.—ACREAGE OF CORN, OATS, AND WHEAT IN MACON COUNTY

The diagram shows the relative acreage devoted to the three principal grain crops at periodic intervals since 1850. (Figures from U. S. Census, except for 1928, for which estimates of the U. S. Bureau of Agricultural Economics and the Illinois State Department of Agriculture are used.)

period has been more than 30 percent and for tame hay about 20 percent, while that for oats has been less than 2 percent. The problem connected with variation in yields per acre is complex but the above figures indicate that the decrease in soil fertility is more than balanced by better farming methods.

The predominance of acreage given over to the growing of corn and oats, as shown in Fig. 2, suggests that more diversification of crops might well be practiced if production is to keep pace with waning fertility. In 1928 the area devoted to alfalfa increased to nearly 2,000 acres, and that of sweet clover to

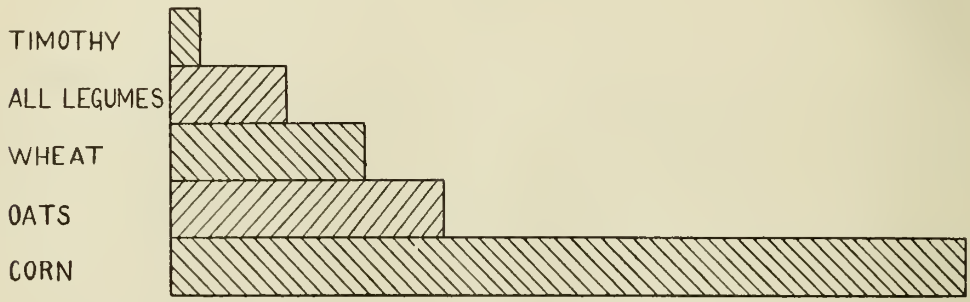


FIG. 2.—RELATIVE ACREAGE OF FIELD CROPS IN MACON COUNTY, 1924

The diagram brings out the preponderance of land devoted to the three grain crops, corn, oats, and wheat. Legume crops might well occupy a larger proportion of the cultivated acreage (data from the 1925 Census).

nearly 4,000. Soybeans have recently become an important crop, replacing some of the oat acreage. In 1928 there were 15,500 acres of soybeans grown in the county, 1,500 acres of which were sown with corn.

Fruit and vegetable crops are not commercially important in Macon county. Some trucking is practiced near Decatur. Practically all such products raised are consumed on the farm or disposed of locally. In 1925 there were 445 acres devoted to vegetables; 185 acres of white potatoes yielded 17,360 bushels; and most of the remaining acreage was in sweet corn. Apples and peaches are the most important fruits. Some grapes are grown.

The number of livestock in the county increased rapidly following 1850, but this increase did not keep pace with the increase in grain production so that Macon soon became a grain-exporting county. Fig. 3 shows the number of horses, mules, cattle, and hogs in the county in certain years during the period from 1850 to the present. The increase from 1870 to 1890 was very marked, especially in the number of hogs. Between 1890 and 1910 there was a sharp decline in total livestock. Since 1910 the number has remained about stationary. A notable decrease in the number of horses and mules occurred between 1920 and 1928. Sheep have never been very numerous in Macon county. There were nearly 10,000 head in 1870, but since then the number has decreased considerably. There have been fewer than 5,000 in the county since 1920.

The character of the livestock interests in the county in 1924 is shown by the following figures taken from the Census:

Animals and Animal Products	*Number*	*Value*
Horses	12,710	$1,028,734
Mules	2,162	188,664
Cattle (total)	21,479	1,011,525
Dairy cows	8,301	......
Dairy products	......	529,026
Sheep	4,211	49,246
Hogs	35,335	477,676
Chickens and eggs sold	......	583,432
Wool	......	6,213

Estimates made by the U. S. Department of Agriculture and the Illinois State Department of Agriculture, as of January 1, 1929, indicate that the number

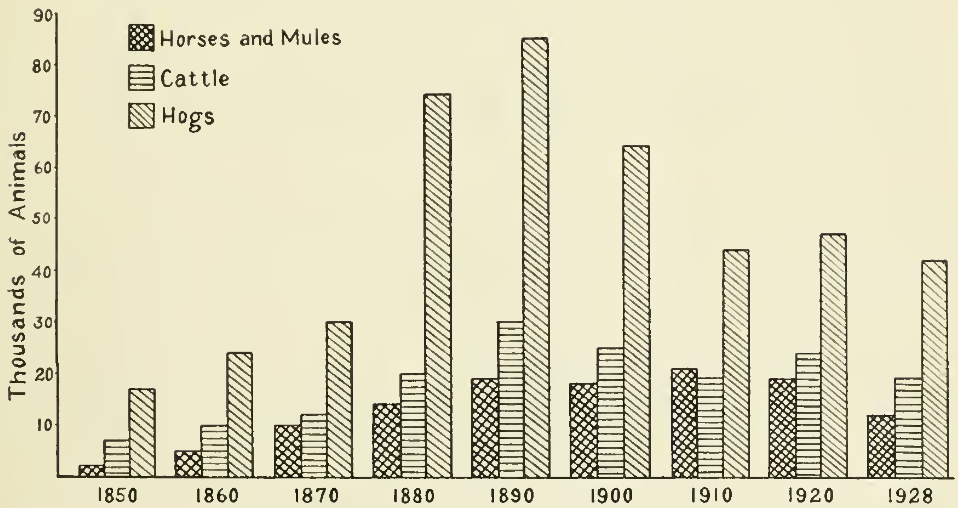


FIG. 3.—NUMBER OF HORSES AND MULES, CATTLE, AND HOGS IN MACON COUNTY

The diagram shows the relative numbers of the principal classes of livestock at periodic intervals since 1850. (Figures from U. S. Census, except for 1928, for which estimates of the U. S. Bureau of Agricultural Economics and the Illinois State Department of Agriculture are used.)

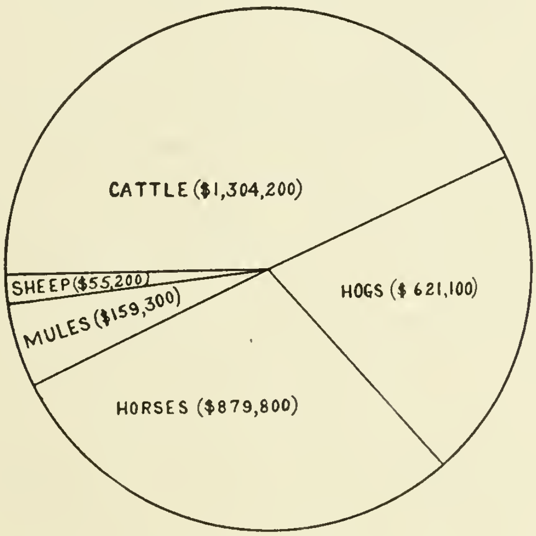


FIG. 4.—RELATIVE VALUE OF THE MORE IMPORTANT CLASSES OF FARM ANIMALS IN MACON COUNTY IN 1929

of horses and mules in Macon county has decreased nearly 3,000 and that of cattle nearly 2,600 since 1925. The number of hogs shows an increase. Fig. 4 shows the relative value of the more important classes of farm animals in 1929. The value of all cattle, as shown in Fig. 4, is nearly as much as that of horses and hogs combined. Mules and sheep are of least importance.

CLIMATE AND PHYSIOGRAPHY

The climate of Macon county, which is typical of the central part of Illinois, is characterized by a wide range between the extremes of winter and summer and by an abundant, usually well-distributed rainfall. The greatest range in temperature for any one year of the thirty-four year period, 1895 to 1929, as recorded at the Weather Bureau Station located in Decatur, was 126 degrees in 1918. The highest temperature recorded was 109° in 1901, the lowest 25° below zero in 1905. The mean summer temperature is about 74°; the mean winter, 29°; and the mean annual, about 52°. The average date of the last killing frost in the spring is April 23; the earliest in fall is October 13. The average length of growing season is 173 days, which is ample for the maturing of the common crops grown in the region. Early frost following a backward season has produced soft corn several times during the last decade, but usually the corn ripens before killing frost comes. Winter wheat is often injured, particularly on flat land, owing to a sudden drop in temperature and consequent freezing following a rainy period in winter or early spring. A short period of extreme hot weather occasionally cuts the yield of small grains in early summer. The temperature in general is, however, favorable for crop growth and maturity.

The prevailing wind direction in spring and summer is southwest; in winter, northwest. Spring winds are usually brisk and those of summer more gentle except before thunder storms. Macon county lies within the region subject to tornadoes but none resulting in serious destruction are known to have visited the county. A series of strong northwesterly gales which bring cold waves, followed by periods of relative calm, characterize the winds of winter.

The average annual rainfall, as recorded at Decatur for the last 34-year period, is 38.07 inches. About half of this amount falls during the growing season. The wettest year on record, 1927, had a total rainfall of 60.58 inches, while 1926 had a total of 58.68 inches. The driest year on record, 1914, had a total rainfall of 25.10 inches. As an illustration of extremes, it is noted that 16.56 inches of rain fell in September, 1926, and only .07 inch in November, 1904. Rainfall in Macon county is so well distributed that there has never been a severe drouth. Occasionally twenty to thirty days pass without much rain so that crop yields are reduced and meadows and pastures are short, but the subsoil has never been thoroly dried out so that plant roots could not obtain moisture. Fig. 5 shows the average monthly distribution of rainfall in the county. Much of the precipitation of the winter months is snow. The average annual snowfall in the county is about 23 inches. Sleet storms are not uncommon. Occasional hailstorms occur in early summer but damage as a result of them is usually local.

The rate at which the rain falls has an important bearing both on moisture available to plants and on soil erosion. No records on the rate of rainfall are

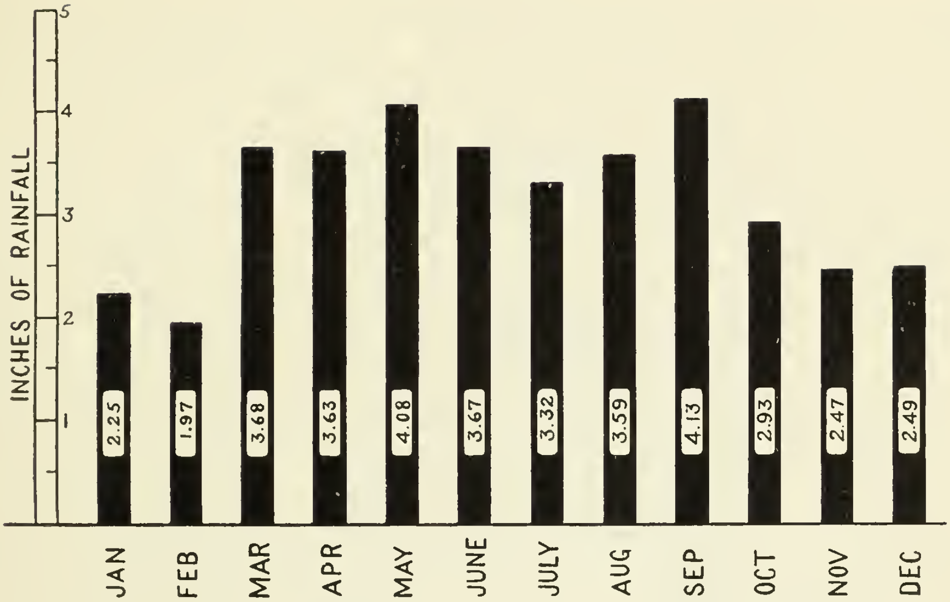


FIG. 5.—THE AVERAGE MONTHLY DISTRIBUTION OF RAINFALL IN MACON COUNTY
It will be noted that the more abundant rainfall occurs mainly during the growing season. This, of course, is favorable to crop production.

available but much of the water which falls, from both prolonged spring rains and hard dashing thunder showers in summer, is perhaps more destructive than beneficial. Several rains of that kind occur in this section almost every year. The control of erosion on cultivated areas, particularly on rolling land, is a serious problem. The accumulation of temporary ponds on flat land following hard rains damages crops by drowning. Losses from erosion and drowning were particularly noticeable during the wet years of 1926 and 1927.

The general elevation of Macon county is between 600 and 700 feet above sea level. The advance and deposit of the last ice sheet to cover central Illinois built up a ridge, the Shelbyville moraine, back of which the land level is some 70 feet higher than below the moraine. This ridge is about three miles wide, extending in a north-south direction just west of the center of the county. The ridge has rolling topography, but otherwise the county is flat to gently rolling except for the narrow rolling strips adjacent to the principal drainage courses. Here the present topography is the effect of erosion. There are two particularly flat-lying regions in the county located in the northwestern and southeastern parts. All the land except a very narrow belt adjoining the Sangamon river bottom land northeast of Decatur can be cultivated. The altitudes of a few towns in Macon county are as follows: Argenta, 692 feet above sea level; Blue Mound, 620; Decatur, 678; Hervey City, 699; Macon, 727; Maroa, 720; Niantic, 606; Oakley, 692; Warrensburg, 709.

Natural drainage in Macon county is fairly well established. Sangamon river and its tributaries drain all but a few sections in the southeast part of the county. Drainage in this area is southeast into Kaskaskia river. The southwestern part of the county drains into South Fork which empties into Sangamon river in Sangamon county. The northwestern part of the county drains into

Lake Fork, a tributary of Salt creek, which flows west emptying into Sangamon river about 30 miles west of the county line. Fig. 6 shows the stream courses, main dredges, and other physiographic features of Macon county.

Much of the original prairie surface in the county was wet and numerous shallow ponds existed because of the lack of an outlet for the water. The extension of natural drainage lines by dredges and ditches has provided proper outlets and this, in addition to tile, has made the land generally well drained. There

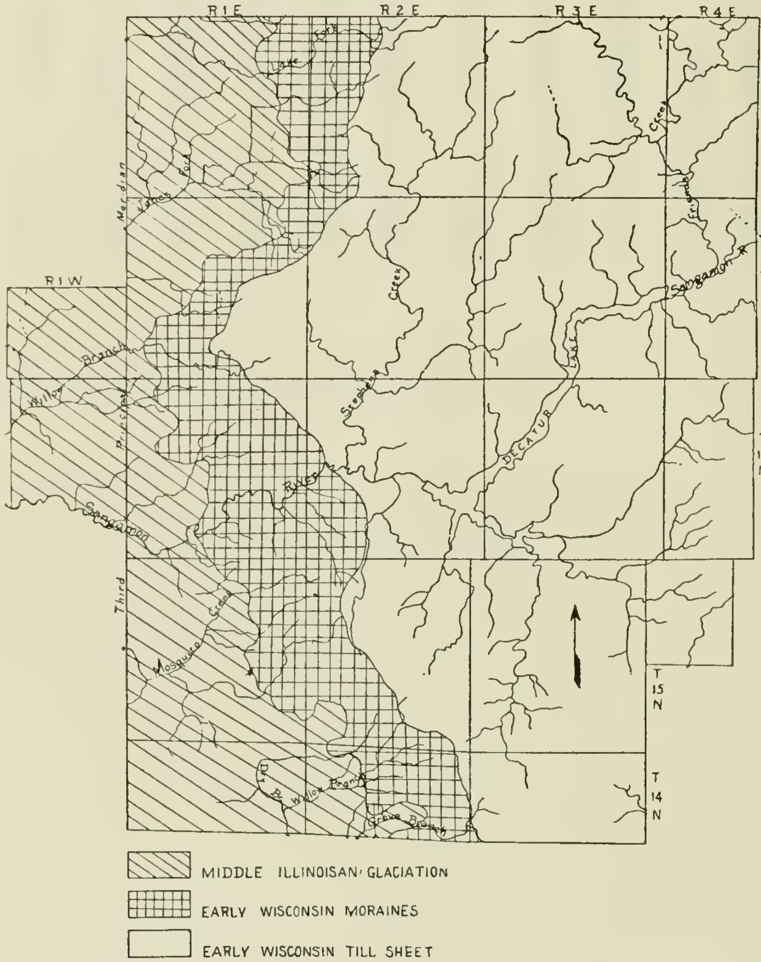


FIG. 6.—DRAINAGE MAP OF MACON COUNTY SHOWING STREAM COURSES AND OTHER PHYSIOGRAPHIC FEATURES

are a few areas, particularly in the northwestern part of the county, which are not yet perfectly drained. Excessive rainfall still causes some damage in the flatter parts of the county because artificial drainage was provided to care for only a moderate amount of run-off.

The soils in the county as a whole are of such nature as to allow freedom of water movement, provided a drainage outlet is established. There are a few areas in the northwestern part of the county and south of the town of Macon with sticky, plastic, and tight subsoil. Special attention must be given to surface ditching to remove excess surface water on these areas, as the subsoil is but slowly pervious to water and tiling alone is not adequate. Except for these few areas, all soils in the county can be properly drained by tiling and good soil moisture conditions maintained.

SOIL FORMATION

ORIGIN OF SOIL MATERIAL

The most important period in the geological history of the county, from the standpoint of soil formation, was the Glacial epoch. The sequence of events of earlier earth history which led to the formation of the bed rock foundation underlying this area is of minor importance because the source of mineral material for the soils as well as the present topography is largely the result of glacial action. It is sufficient to know that the bed rock was formed and elevated to its present position during some remote geological era. The bed rock surface was subject to the forces of rock destruction and removal for an extended period during which the country became rough and broken in character. The hills and valleys produced as a result of erosion were not well suited to agriculture and were in great contrast to the present lay of the land. During the Glacial epoch the material that later constituted the mineral portion of the soils was deposited and the present topography formed.

At the time of the Glacial epoch the climate was colder than at present and snow and ice accumulated in regions to the north in such an amount that the mass pushed outward from these centers. The movement advanced, chiefly southward, aided by further accumulations of snow at its margin, until a place was reached where the climate was warm enough to melt the ice 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, sand, gravel, boulders, and even immense masses of rock. Some of these materials were carried hundreds of miles and rubbed against surface rocks and each other until largely ground into powder. The greater part of material carried was derived from the old eroded bed rock surface and usually deposited less than fifty miles from its origin. When the ice sheet, or glacier, reached the limit of its advance, the rock material carried by it accumulated along the front edge in a broad undulating ridge or moraine. With rapid melting, the glacier receded and the material was deposited somewhat irregularly over the surface of the area previously covered. The advance and recession of the glacier were not uninterrupted movements but were complex in character. Local oscillations of the ice were frequent. 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 115 feet.

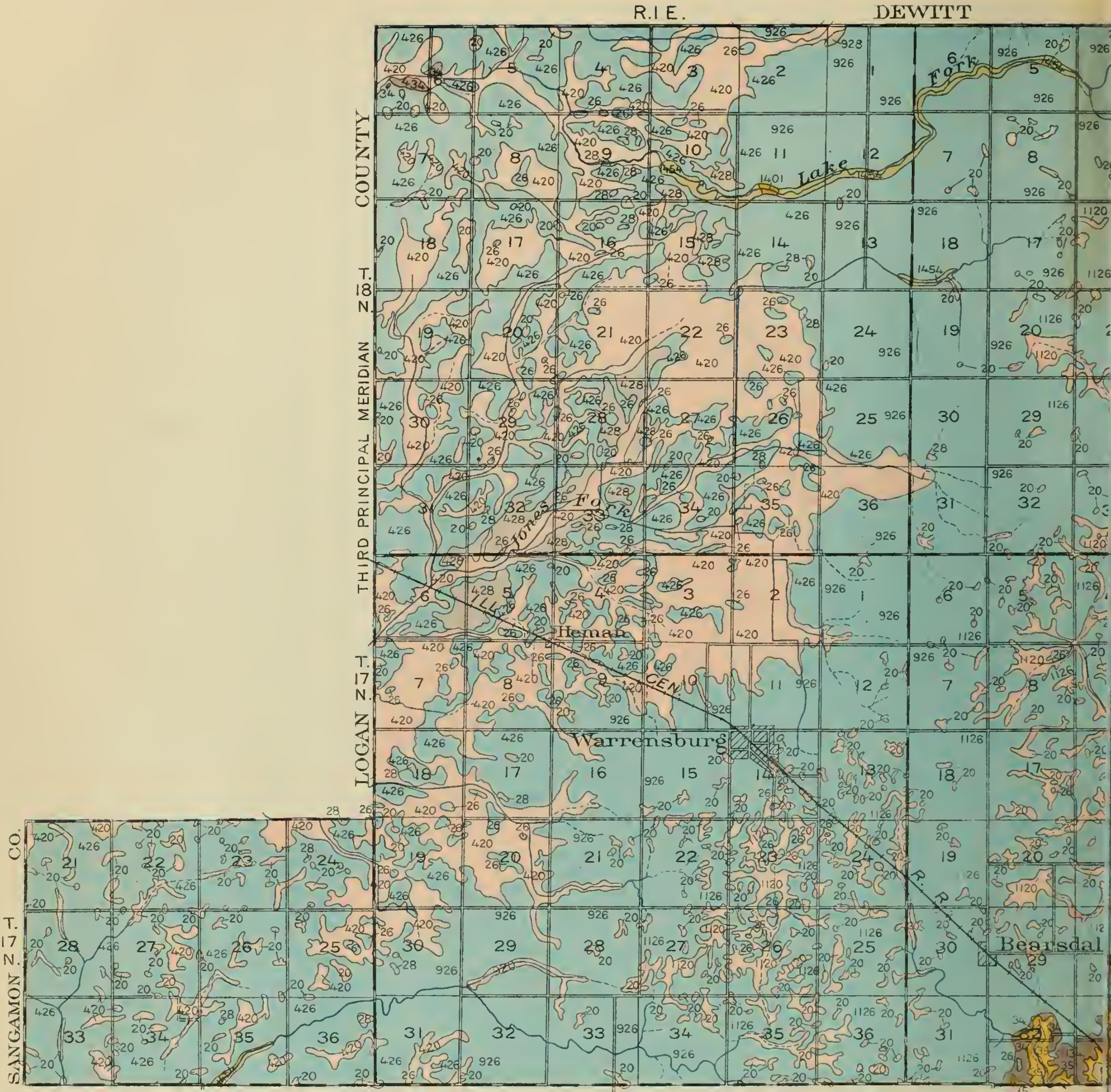
At least six great ice sheets moved southward, each of which covered a part of North America, altho the same parts were not covered during each advance. The advance and retreat of these individual ice sheets were separated by long periods of time during which the climate was normal and the country clothed with vegetation. At least two and perhaps more of the glaciers reached Macon county. The Illinoian glaciation completely covered the county and buried or destroyed the deposits which might have been left by an earlier ice sheet. The last glaciation, known as the Wisconsin, advanced from the northeast across the eastern two-thirds of the county. Its terminus is marked by the broad undulating ridge, known as the Shelbyville moraine, which crosses the county in a north-south direction west of its center (see Fig. 6). This ice sheet deposited from 50 to 120 feet of material over that part of the county which it crossed and on top of the deposit left by the Illinoian. This explains the general higher elevation of the eastern part of the county. Another ridge, known as the Cerro Gordo moraine, was built up during the recession of the Wisconsin glaciation. This moraine enters the county northeast of Oakley and extends in a southwesterly direction, disappearing a few miles north of Casner (see Fig. 6). The topography of that part of the county not covered by the Wisconsin ice sheet is more level and except for a few isolated mounds, such as those one mile west of Blue Mound, the surface is generally flat. The general effect of these glaciers was to change the surface from hilly to gently undulating by filling in the valleys and rubbing down the hills.

Associated with the withdrawal of an ice sheet and exposure of the deposited material to weathering forces was the accumulation of a silty wind-blown material on top of the drift. This wind-blown material is called loess. It was derived largely from the sediment deposited from the immense volumes of water flowing from the ice sheet. This water filled the drainage channels and overflowed adjacent lowlands, forming terraces. Following each flood state, the water would recede and sediment which had been deposited would be picked up by the wind and redeposited on the upland. Undoubtedly some fine material was left on the surface of the drift deposit and more accumulated as the coarser drift particles were broken down. This was blown about by the wind, collecting on the south and west sides of ridges and other obstructions. The lack of vegetation on the land following the recession of an ice sheet gave the wind much more force near the surface than it otherwise would have had.

Most of the loess in that part of the county covered only by the Illinoian glacier was deposited during the time the Iowan ice sheet was melting. The Iowan glacier advance followed the Illinoian and preceded the Wisconsin. It did not touch Macon county but furnished much sediment to the stream valleys from which it was blown across the county. This deposit in turn was partly covered by drift from the Wisconsin glacier. The melting of the Wisconsin ice sheet furnished little sediment to streams so that the loess cover over its deposit is shallow and was largely derived from weathered and fine material on the surface of the drift itself. The thickness of the loess cover overlying the Illinoian drift in the western part of the county varies from 4 to 7 feet, and averages about 5½ feet. The loess deposit on the Wisconsin drift seldom exceeds 3 feet and often is entirely absent.

SOIL DEVELOPMENT

The loess and drift deposits constitute the parent material from which the soils as we know them today have been developed by the forces of weathering. When first deposited, the physical and chemical composition of the loess is very uniform; the drift is less uniform. With the passing of time the various weath-



LE

400 Middle Illinoisan glaciation

900 Early Wisconsin moraines

1100 Early Wisconsin intermorainal area

Scale
0 ¼ ½ 1 2 Miles

(a) UPLAND PRAIRIE SOILS

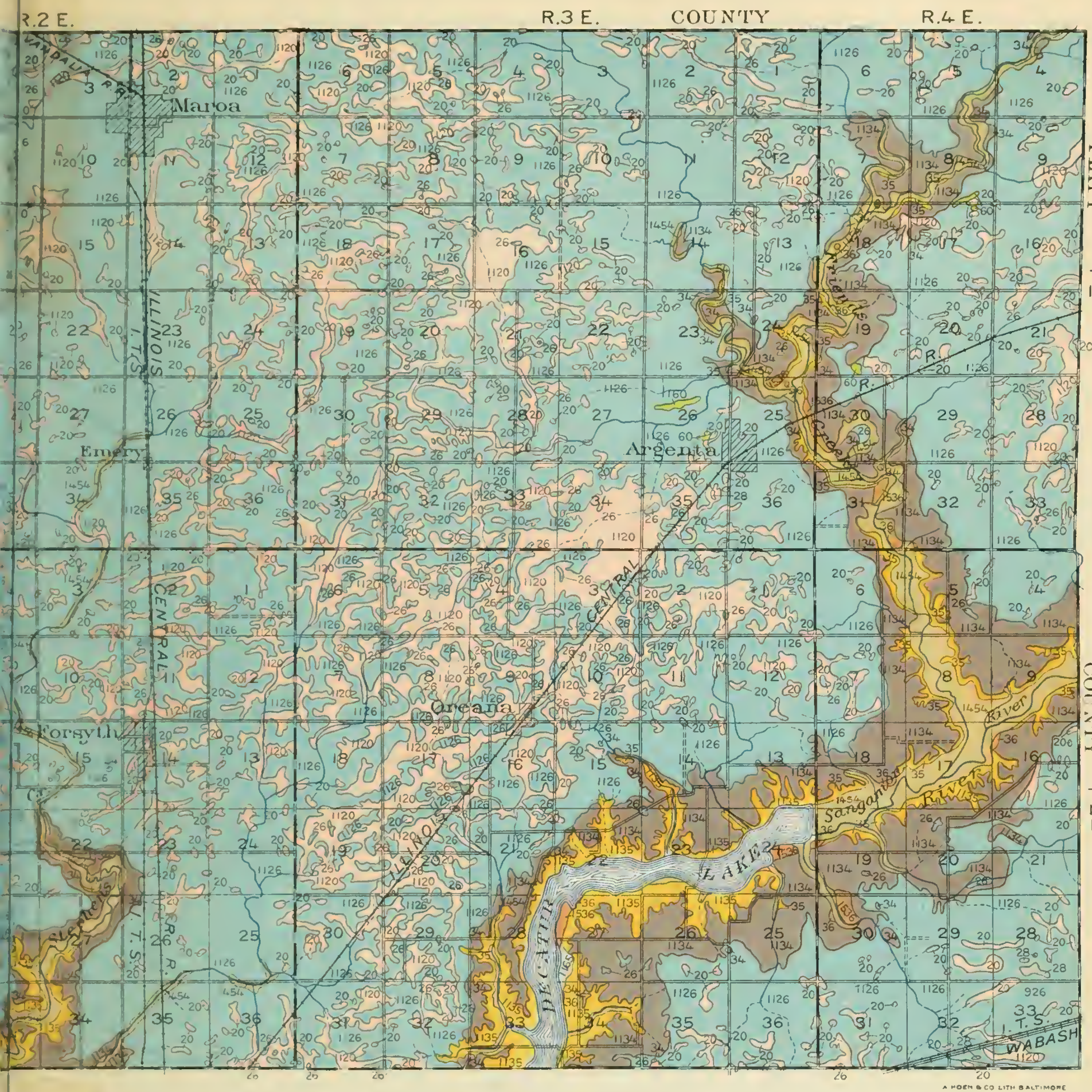
26	Brown silt loam
20	Black clay loam
28	Brown-gray silt loam on tight clay
60	Brown sandy loam

(b) UPLAND TIMBE

34	Yellow-gray silt
35	Yellow silt loam
64	Yellow-gray sanc
65	Yellow sandy loa

SOIL SURVEY MA

UNIVERSITY OF ILLINOIS AGRI



END

SOILS

am

(c) TERRACE SOILS

- 1527 Brown silt loam over sand or gravel
- 36 / 1536 Yellow-gray silt loam over sand or gravel
- 66 / 1566 Brown sandy loam over sand or gravel

(d) LATE SWAMP AND BOTTOM-LAND SOILS

- 1401 Deep peat
- 1426 Deep brown silt loam
- 54 / 1454 Mixed loam

OF MACON COUNTY

ULTURAL EXPERIMENT STATION

ering forces bring about differences in both the physical and chemical composition of the material from the surface down. As these differences develop, the soil profile takes form, and layers, strata, or horizons are formed which are commonly designated as surface, subsurface, and subsoil.

In addition to these vertical differences, horizontal differences also appear so that the soil of one area differs from that of another if the environments of the two areas have been different.

The weathering forces therefore bring about the formation of soils from the original parent material. Each soil is made up of layers or horizons and the character of these layers determines the character of the soil. Thus we have developed soil individuals or soil types. These types differ each from the other either because of differences in the environment under which they were developed, as, for example, height of the water table; or because of differences in the character of the original parent material.

Oxidation, solution, and leaching are important weathering processes. In addition to these, there are others such as freezing and thawing, the action of plant roots and of animals, that have an important part in soil development.

Macon county is geologically so young that the weathering forces have not had time to develop the soils fully and as a result soils are found which are spoken of as young or immature. These soils, because of their youth, still retain a large proportion of the elements of plant food originally present in the parent material. Limestone, which is readily leached, is still present in abundance in the lower subsoil of most of the soil types, tho it has been leached from the surface and subsurface and from the upper subsoil of most of them. The youngest soils in the county are found in the bottoms. The youth, or lack of development, of these soils is explained by the fact that they are subject to frequent overflow and deposition of sediment.

SOIL GROUPS

The accompanying colored soil map, shown in two sections, gives the location and boundary of each soil type, and indicates the position of streams, roads, railroads, and towns. Table 1 gives the list of soil types, the area of each in square miles and acres and also the percentage each constitutes of the total area as recorded on the map. The soil types are arranged into groups in accordance with the geological province in which they are located, the upland soils being further separated on the basis of original vegetative cover. These groups are as follows:

Upland Prairie Soils, dark-colored and usually rich in organic matter, the organic matter having been derived from the decaying roots of the wild prairie grasses which occupied this land for thousands of years.

Upland Timber Soils, those zones along stream courses over which forests grew for a long period of time. These contain in general less organic matter than the prairie soils.

Terrace Soils, including bench lands and second bottoms formed by deposits from flooded streams overloaded with sediment, perhaps at the time of the melting of the glaciers.

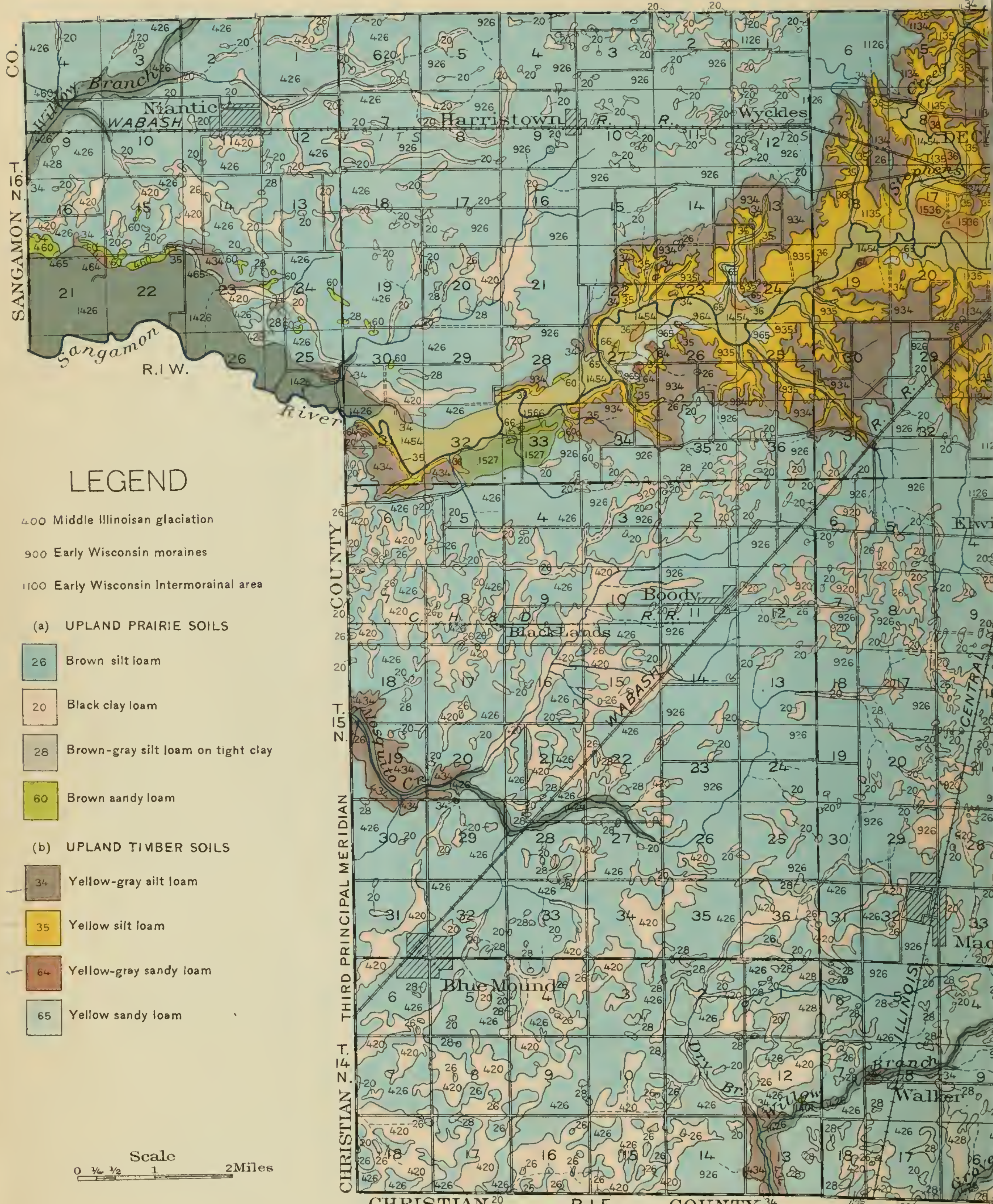
Swamp and Bottom-Land Soils, including the overflow lands or flood plains along streams, the swamps, and the poorly drained lowlands.

The soils of Macon county were surveyed and mapped during the summer of 1914. During the years which have elapsed since the map was made, continued field study and correlative laboratory work have materially increased the knowl-

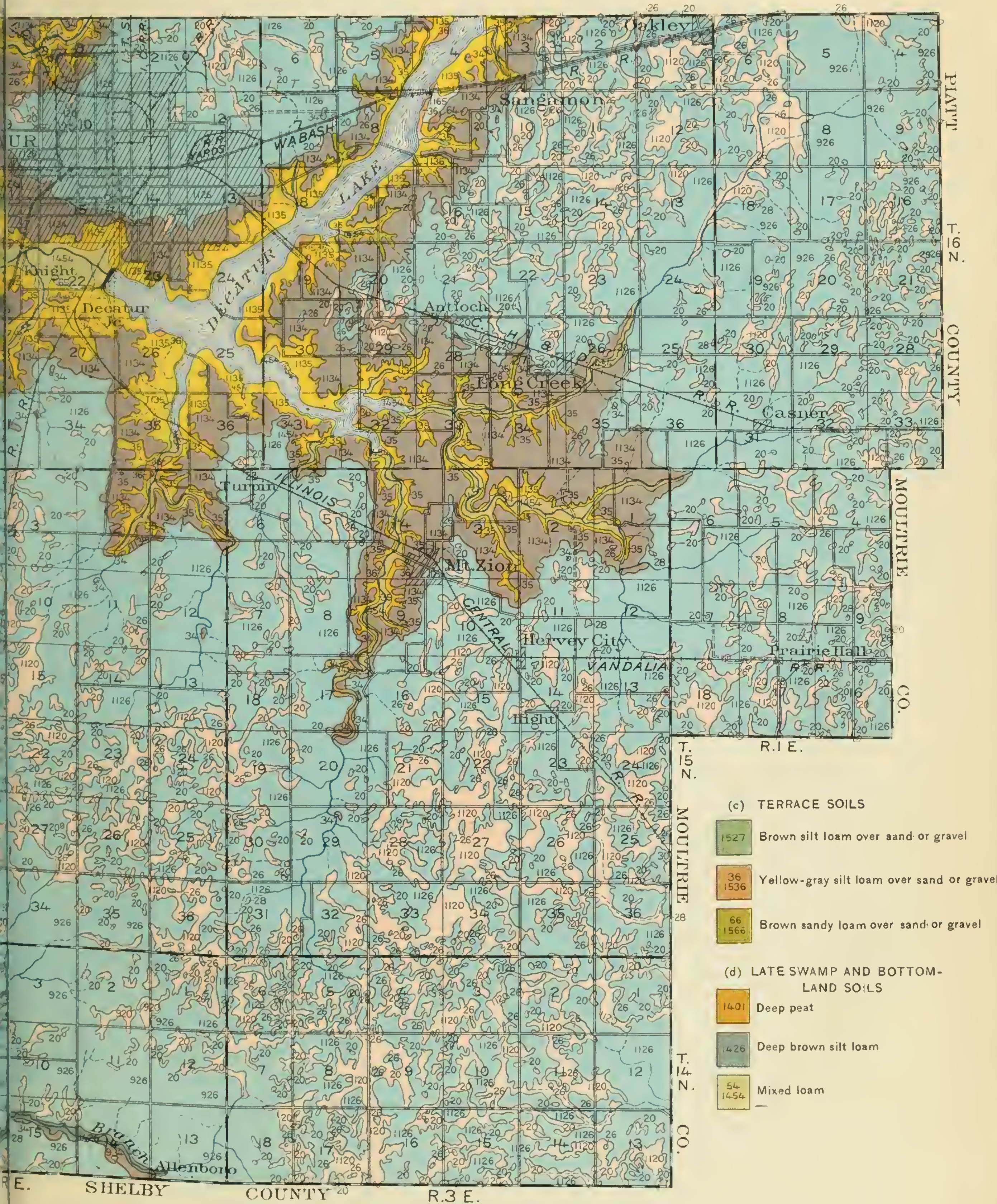
TABLE 1.—SOIL TYPES OF MACON COUNTY, ILLINOIS

Soil type No.	Name of type	Area in square miles	Area in acres	Percent of total area
	Upland Prairie Soils (400, 900, 1100)			
426, 926, 1126	Brown Silt Loam[1]	375.91	240 582	64.71
420, 920, 1120	Black Clay Loam	107.71	68 934	18.54
428, 928, 1128	Brown-Gray Silt Loam On Tight Clay	3.56	2 278	.61
460, 960, 1160	Brown Sandy Loam	.39	250	.07
		487.57	312 044	83.93
	Upland Timber Soils (400, 900, 1100)			
434, 934, 1134	Yellow-Gray Silt Loam	45.27	28 973	7.79
435, 935, 1135	Yellow Silt Loam	20.05	12 832	3.45
465, 965, 1165	Yellow Sandy Loam	.48	307	.09
464, 964, 1164	Yellow-Gray Sandy Loam	.08	51	.02
		65.88	42 163	11.35
	Terrace Soils (1500)			
1536	Yellow-Gray Silt Loam Over Sand or Gravel	1.13	723	.18
1527	Brown Silt Loam Over Sand or Gravel	.61	390	.11
1566	Brown Sandy Loam Over Sand or Gravel	.03	19	.01
		1.77	1 132	.30
	Swamp and Bottom-Land Soils (1400)			
1454	Mixed Loam	14.31	9 158	2.46
1426	Deep Brown Silt Loam	5.70	3 648	.98
1401	Deep Peat	.04	26	.01
		20.05	12 832	3.45
	Lake	5.62	3 598	.97
	Total	580.89	371 769	100.00

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



SOIL SURVEY MA
UNIVERSITY OF ILLINOIS AGRI



OF MACON COUNTY

ULTURAL EXPERIMENT STATION

edge of soils, particularly with reference to classification. The use of soil characters not previously recognized has made it possible to separate soils into more definite units, each having distinct characteristics and differing from one another in agricultural value, and in treatment and fertilizer requirement. At the present time several of the types shown on the map, notably Brown Silt Loam, Black Clay Loam, and Yellow-Gray Silt Loam, would each be divided into several types having definite characteristics. An inspection of the soils of Macon county was made just prior to the publication of this report and in the following discussion these new separations, even tho not shown on the map, are described in such a way that it should not be difficult to recognize each one in the field.

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

INVOICE OF THE ELEMENTS OF PLANT FOOD IN MACON COUNTY SOILS

Three Depths Represented by Soil Samples

In the Illinois soil survey each soil type is sampled in the manner described below and subjected to chemical analysis in order to obtain a knowledge of its important plant-food elements. Samples are taken, usually in sets of three, to represent different strata in the top 40 inches of soil, namely:

1. An upper stratum extending from the surface to a depth of 6⅔ inches. This stratum, over the surface of an acre of the common kinds of soil, includes approximately 2 million pounds of dry soil.
2. A middle stratum extending from 6⅔ to 20 inches, and including approximately 4 million pounds of dry soil to the acre.
3. A lower stratum extending from 20 to 40 inches, and including approximately 6 million pounds of dry soil to the acre.

By this system of sampling we have represented separately three zones for plant feeding. It is with the upper, or surface layer, that the following discussion is mostly concerned, for it includes the soil that is ordinarily turned with the plow and is the part with which the farm manure, limestone, phosphate, or other fertilizing material is incorporated. Furthermore it is the only stratum which can be greatly changed in composition as a result of adding fertilizing materials.

For convenience in making application of the chemical analyses, the results presented in Tables 2, 3, and 4 are given in terms of pounds per acre. It is a simple matter to convert these figures to a percentage basis in case one desires to consider the information in that form. In comparing the composition of the different strata, it must be kept in mind that it is based on different quantities of soil, as indicated above. The figures for the middle and lower strata must therefore be divided by two and three respectively before being compared with each other or with the figures for the upper stratum.

Wide Range in Organic Matter and Nitrogen

It can be readily seen from Table 2 that there is a wide variation among the different soil types of Macon county with respect to their content of the different plant-food elements in the upper 6⅔ inches of soil. The most striking relationship among these variations is observed with respect to organic carbon and nitrogen, the quantities of which run parallel from type to type tho the organic-carbon content is usually 10 to 12 times as great as the nitrogen. This relationship between organic carbon and nitrogen is explained by the well-established facts that all soil organic matter (of which organic carbon is the measure) contains nitrogen, and that most of the soil nitrogen—usually 98 percent or more—is present in a state of organic combination, that is, as a part of the organic matter.

The upland prairie soils of Macon county are, for the most part, relatively high in organic matter and nitrogen, while the upland timber soils are fairly low, there being no overlapping in the two groups with respect to these constituents. This difference is noticeable, not only in the surface soil, but in the middle and lower strata as well. In addition to the upland timber types, Brown Sandy Loam as found both in the upland prairie group and on the terrace is noticeably low in its content of organic carbon and nitrogen. Sandy soils, owing to their porous character, permit the rapid oxidation of organic matter, so that its accumulation is more difficult than in heavier soils.

All of the soils of the county diminish rapidly in their content of both organic matter and nitrogen with increasing depth. This diminution is noticeable in the second stratum, 6⅔ to 20 inches, and is very pronounced in the lower stratum, 20 to 40 inches.

Phosphorus Lower in Light-Colored Soils

The total phosphorus content varies somewhat from type to type. As with organic matter and nitrogen, it is noticeably low in the light-colored upland timber soils and in Brown Sandy Loam. The least amount, 540 pounds per acre, occurs in Yellow Sandy Loam, the type which is also lowest in nitrogen and organic carbon, while the greatest amount of phosphorus, 1,640 pounds per acre, is found in Black Clay Loam, the type which shows the largest amounts of nitrogen and organic carbon. There is a tendency for the phosphorus content of soils to parallel the organic carbon to some extent, but not closely as does nitrogen. Phosphorus, in contrast with some other elements, is not appreciably removed from the soil by leaching. It is converted by growing plants into organic forms and tends to accumulate in the surface soil in plant residues at the expense of underlying strata. Investigations at the Illinois Station have shown that in Brown Silt Loam, for example, about 33 percent of the total phosphorus of the surface soil is organic, and in Black Clay Loam about 37 percent. It is the second stratum which furnishes most of the phosphorus thus moved upward. Consequently, the phosphorus percentage is generally higher in the surface soil than in the second stratum, and frequently higher than in the lower stratum. It is the upland timber soils, which do not accumulate much organic matter in the surface stratum, that constitute the chief exceptions to this general trend.

Sulfur Generally Well Supplied

Sulfur, another element used by growing plants, is likewise associated to some degree with 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 organic matter. The soils of Macon county contain from less than one-half to about three-fourths as much sulfur as phosphorus, the amount in the surface soil ranging from 270 to 1,080 pounds per acre. Like phosphorus, the sulfur content generally decreases with depth, partly because a portion of the sulfur is organic, and organic matter decreases with depth, and partly because organic sulfur is less subject to leaching than calcium sulfate (gypsum), the chief inorganic form found in soils.

The quantity of sulfur available to crops is determined not only by the soil supply, but also by the amount brought down from the atmosphere by rain. Sulfur dioxid escapes into the air in the gaseous products from the burning of all kinds of fuel, particularly coal. The gaseous sulfur dioxid is soluble in water and consequently is dissolved out of the air by rain and brought to the earth. In regions of large coal consumption, the amount of sulfur thus added to the soil is relatively large. At Urbana during the eight-year period from 1917 to 1924 there was added to the soil by the rainfall an average of 3.5 pounds of sulfur an acre a month. Similar observations have been made in other localities for shorter periods. The precipitation at various points in the state in a single month is found to vary from a minimum of ¾ of a pound to more than 10 pounds an acre.

These figures afford some idea of the amounts of sulfur added by rain, and also of the wide variations in amount under different conditions. Considering the amounts which are brought down in rainfall in addition to the soil supply, the facts would indicate that apparently there is little or no need for sulfur fertilizers in Macon county. In order to determine definitely the response of crops to applications of sulfur fertilizers, experiments with gypsum have been started on a number of experiment fields in various parts of the state.

Potassium Content Comparatively Uniform

The potassium content of Macon county soils shows relatively less variation from type to type than any other element studied. The average amount in the surface soil is approximately 32,000 pounds an acre, and the entire range thru all the types in the county is from a minimum of 24,140 pounds up to 37,660 pounds per acre. The potassium concentration in the soil at different depths likewise shows very little variation.

Wide Variations in Calcium and Magnesium

Soils generally exhibit wide variations in calcium and magnesium content, and this is found to be the case in Macon county. In the surface soil magnesium varies from a minimum of 2,860 pounds per acre in Yellow Sandy Loam to 15,250 pounds in Black Clay Loam. This latter type also contains the highest amount of calcium found in the county, namely, 22,330 pounds an acre, while the minimum, 5,120 pounds an acre, occurs in Brown Sandy Loam, Terrace.

Aside from the calcium which may be in solution in the soil water, soil calcium exists primarily in three forms. *Calcium-aluminum silicates* are complex soil minerals which decompose but slowly and furnish but scant amounts of soluble calcium for plant growth. This is the form which predominates in most soils, particularly those which are highly acid. Calcium may be deficient as a plant-food element in such soils, so that the supplying of this element may be one of the benefits of liming. Calcium also occurs in association with the soil colloids (the finest of the clay particles), where it is absorbed; this is known as *replaceable calcium,* and is much more easily obtainable by growing plants than the mineral form above mentioned. It is found more abundantly in the soils which are non-acid or only slightly acid. Types are occasionally found that grow sweet clover luxuriantly because of the abundance of replaceable calcium which they contain, even tho they may be distinctly acid. *Calcium carbonate,* the form contained in limestone, is the third form of calcium in soils. It occurs only in alkaline (sweet) soils. Black Clay Loam in Macon county usually carries calcium carbonate in all three strata. This is indicated by the high calcium content shown in Tables 2, 3, and 4, which, it will be noted, becomes increasingly greater in passing from the upper to the lower stratum. This downward movement of dissolved calcium carbonate in the soil water is a result of leaching and accounts for its greater concentration at lower depths. Some increase in total magnesium accompanies the high calcium of these carbonate-containing strata. The increases are not great, however, because of the inability of magnesium to exist long in the soil in the form of carbonate. The carbonate of carbonate-containing soils is chiefly calcium carbonate.

In the upland soils variations in the amounts of calcium and magnesium at the different depths give some indication of the relative movement of these elements in soil formation. In the surface soil the calcium usually exceeds the magnesium in amount, as a result of the preponderance of calcium in the soil-forming materials. As these two bases are carried downward in solution, magnesium is more readily absorbed than calcium by the soil colloids, so that with increasing depth there is an increasing proportion of magnesium to calcium. This change is more pronounced in the mature soils such as Brown-Gray Silt Loam On Tight Clay, where the ratios of magnesium to calcium in the upper, middle, and lower strata, are, respectively, .76, .94, and 1.48. That is, in the surface soil there is only about three-fourths as much magnesium as calcium. In the second stratum these two elements are about equal, while in the lower stratum there is about one and one-half times as much magnesium as calcium. In youthful soils, where the leaching has been less intense or less prolonged, the ratio of magnesium to calcium shows little or no increase in the lower levels. For instance, in Black Clay Loam the ratios of magnesium to calcium are, in the three respective strata, .69, .74, and .56. Here the drop in the *relative* amount of magnesium in the lower stratum is an expression of the calcium carbonate accumulation noted above. It is worth while to note that the two sandy types in this county show neither an appreciable increase in the amount of calcium or magnesium with increasing depth, nor a change in the ratio of these elements to each other. These soils contain so little colloidal material that they have but little ability to absorb these bases as they are carried downward by percolating water.

From these observations, it is obvious that at least some of the various processes involved in soil development are definitely reflected in the chemical properties of the soil itself. These, in turn, may be related to agricultural utilization and fertility requirements.

Local Tests for Soil Acidity Often Required

It is impracticable to attempt to obtain an average quantitative measure of the calcium-carbonate content or the acidity of a given soil type because, while some samples will contain large amounts of calcium carbonate (as in some subsoils of Macon county), others will contain none, but on the other hand, may have a lime-requirement due to the soil acidity. We thus have what may be considered positive and negative values ranging, perhaps widely, on the opposite sides of the zero or neutral point. The numerical average of such values could have no significance whatever, since such an average would not necessarily even approach the condition actually existing in a given farm or field. It is for this reason that the tables contain no figures purporting to represent either the lime requirement or the limestone present in the different soil types.

The qualitative field tests made during the process of the soil survey are much more numerous than the chemical analyses made in the laboratory, and do give a general idea of the predominating condition in the various types as to acidity or alkalinity. These tests, therefore, furnish the basis for some general recommendations which are given in the descriptions of individual types on pages 21 to 29. To have a sound basis for the application of limestone the owner or operator of a farm will usually find it desirable to determine individually the lime requirements of his different fields. The section in the Appendix dealing with the application of limestone (page 38) is pertinent and should be read in this connection.

Supplies of Elements Not Proportional to Crop Removal

In the foregoing discussion we have considered mainly the amounts of the plant-food elements in the surface 6⅔ inches of soil, and rather briefly the relative amounts in the two lower strata. We have noted that some of the elements of plant food exhibit no consistent change in amount with increasing depth. Other elements show more or less marked variation at the different levels, the trend of these variations serving in some cases as clues to the relative maturity of different soil types and the processes involved in their development.

By adding together the figures for all three strata for a given type, we have an approximate invoice of the total plant-food elements within the feeding range of most of our field crops, since the major portion of their feeding range is included in the upper 40 inches. One of the most striking facts brought out of this consideration of the data is the great variation within a given soil type in the relative abundance of the various elements present as compared with the amounts removed by crops. In one of the important types in the county, Brown

Silt Loam, Upland, we find that the total quantity of nitrogen to a depth of 40 inches is 14,190 pounds. This is about the amount of nitrogen contained in the same number of bushels of corn. The amount of phosphorus is approximately one-third as much, or 4,480 pounds, but this amount is equivalent to the phosphorus in nearly twice as much corn, namely, 26,350 bushels. In the surface stratum, however, which is the zone of most intensive crop feeding, we find the relative amounts of nitrogen and phosphorus more nearly in accord with the rate of removal of these elements by crops. Here the nitrogen is equivalent to 4,200 bushels of corn, and the phosphorus to 5,500 bushels.

TABLE 2.—MACON COUNTY SOILS: PLANT-FOOD ELEMENTS IN UPPER SAMPLING STRATUM, ABOUT 0 TO 6⅔ INCHES
Average pounds per acre in 2 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (400, 900, 1100)							
426, 926, 1126	Brown Silt Loam	51 180	4 200	940	690	35 209	7 190	9 890
420, 1120	Black Clay Loam	67 100	7 300	1 640	1 080	33 770	15 250	22 330
428	Brown-Gray Silt Loam On Tight Clay	38 430	3 370	1 060	670	33 510	5 210	6 840
460	Brown Sandy Loam	22 360	1 500	600	320	26 540	3 580	6 180
	Upland Timber Soils (900, 1100)							
934, 1134	Yellow-Gray Silt Loam	20 630	1 770	660	500	35 730	4 830	7 330
935, 1135	Yellow Silt Loam	21 350	1 900	690	270	33 870	5 940	7 180
964, 1164	Yellow-Gray Sandy Loam[1]	......	......	......	......	......	......	......
965	Yellow Sandy Loam	17 800	1 400	540	380	27 580	2 860	6 560
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	42 080	4 020	960	860	36 000	6 500	7 040
1536	Yellow-Gray Silt Loam Over Gravel	31 720	2 480	1 060	420	37 660	5 020	8 320
1566	Brown Sandy Loam	24 040	1 800	720	440	24 140	4 100	5 120
	Swamp and Bottom-Land Soils (1400)							
1401	Deep Peat[1]	......	......	......	......	......	......	......
1426	Brown Silt Loam	43 160	3 600	1 240	520	31 580	7 620	10 960
1454	Mixed Loam[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]No samples were collected representing Yellow-Gray Sandy Loam and Deep Peat because of the limited area in the county occupied by these types. See pages 27 and 29.

[2]The results of chemical analyses of Mixed Loam are not included on account of the heterogeneous character of this type.

Other types show marked contrast to Brown Silt Loam, just discussed, with respect to their content of the various plant-food elements in relation to rate of removal by crops. However, in most soils, except those which are peaty, total phosphorus is more abundant than total nitrogen when considered in terms of crop equivalents rather than the actual number of pounds an acre of the respective elements.

Service of Chemical Investigations in Soil Improvement

The foregoing discussion should not be taken to mean that it is possible to predict how long any certain soil could be cropped under a given system before it would become exhausted. Nor do the figures alone indicate the immediate procedure to be followed in the improvement of a soil. It must be kept in mind that the *amount* of plant food shown to be present is not the sole measure of

TABLE 3.—MACON COUNTY SOILS: PLANT-FOOD ELEMENTS IN MIDDLE SAMPLING STRATUM, ABOUT 6⅔ TO 20 INCHES

Average pounds per acre in 4 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (400, 900, 1100)							
426, 926, 1126	Brown Silt Loam	66 880	5 920	1 560	1 100	70 980	17 920	19 030
420, 1120	Black Clay Loam	72 900	6 830	2 600	1 410	68 050	31 500	42 420
428	Brown-Gray Silt Loam On Tight Clay	38 400	3 140	1 420	720	71 880	12 460	13 240
460	Brown Sandy Loam	24 000	1 650	1 200	680	54 360	8 200	10 360
	Upland Timber Soils (900, 1100)							
934, 1134	Yellow-Gray Silt Loam	16 430	1 920	1 330	730	73 560	22 770	17 120
935, 1135	Yellow Silt Loam	18 980	1 860	1 540	420	80 000	18 300	13 220
964, 1164	Yellow-Gray Sandy Loam[1]	......	......	......	......	......	......	......
965	Yellow Sandy Loam	20 920	1 520	1 240	440	56 440	6 520	13 120
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	59 720	5 320	1 640	1 200	73 520	15 520	14 120
1536	Yellow-Gray Silt Loam Over Gravel	23 480	2 320	1 800	920	79 040	14 720	14 600
1566	Brown Sandy Loam	44 520	3 400	1 480	920	50 720	10 040	11 120
	Swamp and Bottom-Land Soils (1400)							
1401	Deep Peat[1]	......	......	......	......	......	......	......
1426	Brown Silt Loam	54 280	4 680	1 720	760	49 680	13 520	18 960
1454	Mixed Loam[2]	......	......	......	......	......	......	......

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

[1]No samples were collected representing Yellow-Gray Sandy Loam and Deep Peat on account of the limited area in the county occupied by these types. See pages 27 and 29.

[2]The results of chemical analyses of Mixed Loam are not included because of the heterogeneous character of this type.

the ability of a soil to produce crops. The *rate* at which these elements are liberated from insoluble forms and converted to forms that can be used by growing plants is a matter of at least equal importance (as explained on page 36) and is not necessarily proportional to the total stocks present. One must know, therefore, how to cope with the peculiarities of a given soil type if he is to secure the full benefit from its stores of the plant-food elements. In addition there are always economic factors that must be taken into consideration, since it is necessary for the farmer to decide at how high a level of productive capacity he can best afford to maintain his soil.

The chemical investigations carried out in connection with the soil survey, of which the analyses here reported are a part, are of value chiefly in two ways. In the first place, they reveal at once outstanding deficiencies or other chemical

TABLE 4.—MACON COUNTY SOILS: PLANT-FOOD ELEMENTS IN LOWER SAMPLING STRATUM, ABOUT 20 TO 40 INCHES
Average pounds per acre in 6 million pounds of soil

Soil type No.	Soil type	Total organic carbon	Total nitrogen	Total phosphorus	Total sulfur	Total potassium	Total magnesium	Total calcium
	Upland Prairie Soils (400, 900, 1100)							
426, 926, 1126	Brown Silt Loam	45 360	4 070	1 980	1 060	111 010	41 800	35 400
420, 1120	Black Clay Loam	49 090	3 840	3 020	1 150	101 570	66 140	118 510
428	Brown-Gray Silt Loam On Tight Clay	30 390	3 390	2 460	450	108 390	34 260	23 070
460	Brown Sandy Loam	23 820	1 600	1 440	540	76 080	9 120	15 720
	Upland Timber Soils (900, 1100)							
934, 1134	Yellow-Gray Silt Loam	17 000	2 300	2 300	900	114 560	38 220	24 540
935, 1135	Yellow Silt Loam	20 160	2 280	2 610	390	117 750	36 690	20 820
964, 1164	Yellow-Gray Sandy Loam[1]	......	......	......	......	......	......	......
965	Yellow Sandy Loam	20 640	1 320	1 620	300	71 820	10 260	20 100
	Terrace Soils (1500)							
1527	Brown Silt Loam Over Gravel	41 100	4 020	2 160	1 380	110 100	31 440	19 740
1536	Yellow-Gray Silt Loam Over Gravel	19 260	2 400	3 120	720	116 820	34 320	25 380
1566	Brown Sandy Loam	40 260	2 580	1 560	1 200	75 360	17 160	15 840
	Swamp and Bottom-Land Soils (1400)							
1401	Deep Peat[1]	......	......	......	......	......	......	......
1426	Brown Silt Loam	37 500	3 300	1 980	840	92 160	21 420	24 300
1454	Mixed Loam[2]	......	......	......	......	......	......	......

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

[1]No samples were collected representing Yellow-Gray Sandy Loam and Deep Peat on account of the limited area in the county occupied by these types. See pages 27 and 29.

[2]Results of chemical analyses for Mixed Loam are not included on account of the heterogeneous character of this type.

characteristics which alone would affect soil productivity to a marked extent, or point the way to corrective measures. It should be borne in mind, however, that fairly wide departures from the usual composition are necessary before the chemical analysis alone can be followed as a guide in practice without supplementary information from other sources. It is probable that the results of chemical soil analyses are frequently misused by attempting to interpret small differences in the amount of a certain plant-food element as indicative of similar differences in the fertilizer need. For example, differences of 100 or 200 pounds of phosphorus per acre in soils containing 1,000 pounds or thereabout in the surface soil should not be considered as indicating a corresponding difference in response to phosphate fertilization. Again, 100 pounds to the acre of active nitrogen added by plowing down a clover crop may be of more importance to the succeeding crop than a difference in soil composition of 1,000 pounds an acre of nitrogen. An example of the direct use of the results of chemical investigations is the marked shortage of potassium in peat soils associated with the need for potassium fertilizers; another case is the determination of the lime need of soils by chemical tests.

The second use of chemical methods is in the more detailed study of soils. The processes of soil development leave their imprint upon the soil both in its physical conformation and also in its chemical characteristics. Likewise every operation in the handling of the soil and every application of fertilizer or liming material disturbs its equilibrium, setting up new reactions, which are in turn reflected in variations in crop adaptability, producing capacity, and agricultural usefulness. Chemistry is a most important tool in tracing and characterizing such changes, and chemical investigations are undertaken with the aim of aiding in the classification of soils as well as making possible more accurate prediction of their agricultural value and fertility needs, and response to different methods of management.

DESCRIPTION OF SOIL TYPES

UPLAND PRAIRIE SOILS

The upland prairie soils of Macon county occupy 487.57 square miles, more than four-fifths of the total area of the county. These soils are brown to black in color. There is, however, considerable difference in the color, not only of the various types, but within types, particularly in the case of Brown Silt Loam. The character of the subsoil is also notably different, varying from a loose, open, well-drained silt loam to a compact, sticky, and slowly pervious clay. The dark color of the prairie soils is due to an accumulation of organic matter from the fibrous roots of the prairie grasses that grew for centuries on this land prior to its cultivation by man. A covering of fine soil and a mat of vegetative material, by partially excluding the oxygen, protected these roots from rapid and complete decay. From time to time the mat of old grass stems and leaves was partially destroyed by prairie fires and decay, but it was constantly being renewed, and while it added little organic matter to the soil directly, it served to retard the decay of the roots of the grasses.

Brown Silt Loam (426, 926, 1126)

Brown Silt Loam, as mapped in Macon county, occupies 375.91 square miles, about two-thirds of the total area of the county. It varies in character depending on topography and in the kind of mineral material from which it has been derived, and it would now be separated into at least four distinct types. Each of these is described below so that it may be recognized in the field.

1. **Light Brown Silt Loam.** This type occurs on the higher, rolling areas where surface drainage is good. It is limited to the knolls in the southwestern part of the county and to that outer portion of the Shelbyville moraine from which erosion has not removed the silty deposit. Occasionally small areas are found on the rolling land near stream valleys. It covers only a very small percent of the total area of the county. The surface soil is about 6 inches thick and is a light brown or yellowish brown silt loam. The subsurface, extending to a depth of 15 inches, is a loose, yellowish brown silt loam. The upper subsoil is an open, dark reddish yellow, silty clay loam. The lower subsoil which is found at depths of 25 to 30 inches is a very open, grayish yellow, silt loam. The soil is very well drained.

Management.—The surface slope of this type of soil is such that sheet erosion is active. Care must be exercised to prevent washing either by keeping a cover of vegetation or by terracing. The soil is not high in organic matter and nitrogen and it is medium acid. Limestone should be applied at the rate of 2 to 3 tons an acre, and clover grown and turned under every three or four years as a source of organic matter and nitrogen. As this type usually occurs in small areas, it makes an excellent location for alfalfa. After liming it is especially suited to the growing of alfalfa and other legumes. The best information available on the treatment of this type comes from the Mt. Morris and Dixon experiment fields which are located in part on Light Brown Silt Loam. The results from these fields show a very marked response to manure. Limestone in addition to manure has given a further increase sufficiently large to pay a good profit on the cost of the limestone. Limestone with residues has been another profitable treatment. Neither potash nor rock phosphate applications have increased yields sufficiently to be profitable on this soil type. The reader is referred to the summarized yields on the Mt. Morris and Dixon fields found on pages 49 to 53 of this report.

2. **Brown Silt Loam.** This type occupies intermediate topographic positions and is by far the most extensive type in the county. It is rather uniformly distributed but is not so prevalent near main stream courses or in very flat areas as elsewhere. The surface soil is about 8 inches thick and has a dark brown color. The subsurface is a somewhat lighter brown than the surface. The subsoil begins at 18 inches and is a brownish yellow, somewhat compact, clay loam. The lower subsoil is friable and yellowish and begins at about 30 to 34 inches.

Management.—This type of soil drains well and is not subject to severe erosion. It was originally well supplied with organic matter but continued cropping has reduced the supply considerably. The soil is acid and requires at least 2, and possibly 2½, tons an acre of limestone to grow alfalfa, sweet clover, or the best red clover. The Kewanee experiment field is located, for the most part, on this soil type. Unfortunately, the Kewanee field has several draws crossing the plots which are a much heavier soil, so that the results from the field cannot be applied to Brown Silt Loam with as much confidence as would otherwise be the case. It is, however, almost certainly true that the presence of the heavier soil on the Kewanee field has the effect of diminishing the increases due to treatment. This field shows very good results for manure on corn and oats, but less effect on wheat. Limestone gives a more profitable return used in the residues system than with manure, but in each case the increases were satisfactory. Rock phosphate has produced a profitable return in the residues system but has failed to pay for its cost in the manure system. The Bloomington field, which is located in part on this same soil type, has responded very markedly to the application of phosphates. The suggestion therefore is that if manure is not available, one of the phosphates be applied for wheat after the nitrogen needs are met by the growing of legumes. Summarized results from the Kewanee and Bloomington fields are given in the Supplement to this report on pages 53 to 59.

3. **Brown Silt Loam On Clay.** This type occupies the nearly level or very gently sloping areas and is largely confined to the northwestern, southwestern, and southeastern parts of the county. It is closely associated with Black Clay Loam but lies on higher ground and has a more sloping surface. It is not extensively developed even in these flat areas. The surface soil is a dark brown silt loam, 10 inches thick. The subsurface is similar to the surface in color but heavier in texture, usually a heavy, silty clay loam. The upper subsoil begins at 18 to 20 inches and is a brownish yellow, compact, plastic clay loam. The lower subsoil, beginning at 36 inches or deeper, is a silty clay loam, yellow in color, and spotted with reddish brown. It is more friable than the upper subsoil.

Management.—The lack of sufficient surface slope and the compact plastic subsoil of this type makes artificial drainage necessary. Tile will draw well and if a proper outlet is maintained, the soil can be adequately drained by tiling. This type is only slightly acid. It will grow red clover without lime but 1½ to 2 tons an acre of limestone is necessary to insure alfalfa or sweet clover stands. Unless these two legume crops are to be grown, the use of limestone could hardly be advised. The Aledo experiment field most nearly represents this soil type and the results from this field may be used as a guide in its treatment. (See page 59). Rock phosphate has not caused significant increases in yield on the manure plots. On the residues plots some increase in yield has followed its use but the increases have not been sufficiently large to justify advising its use. Comparisons of phosphorus carriers are being made on the Aledo field. The results show that acid phosphate, bone meal, and slag phosphate all rank slightly ahead of rock phosphate on this soil. It is suggested that a trial application of one of the phosphate fertilizers be made before using phosphate in a large way.

4. **Brown Silt Loam On Drift.** This type occupies the sloping areas on the knolls and ridges and near small stream courses from which erosion has removed some of the silty surface material. It is not extensive and occurs principally on the Shelbyville and Cerro Gordo moraines. The surface soil is about

7 inches thick and light brown in color. The subsurface is thin and is yellowish brown in color. The upper subsoil is slightly compact, is brownish yellow in color, and is often sandy or gravelly. The lower subsoil is yellow and is a mixture of sand, gravel, and clay. Where erosion is active, the gravelly subsoil is near enough to the surface to make the soil drouthy during dry seasons. The calcareous drift is usually 40 to 45 inches below the surface but in the eroded areas it is often as shallow as 25 inches.

Management.—Protection from erosion as suggested for Light Brown Silt Loam is also suggested for this type. The surface soil is medium acid, but as the sweet subsoil is nearer the surface in this type, an application of 2 tons of limestone is all that is required for a successful stand of sweet clover or alfalfa. Red clover will grow without lime but some lime is needed for a good stand. There is no experiment field located on this soil type but from its nature and the results of yields on associated soil types, it is suggested that a trial of the phosphates be made, as some of them may prove profitable. One of the potash salts might also be beneficial if applied on corn and it is suggested that this be first tried experimentally before applying to large fields. Potash salts should be applied at the rate of about 75 pounds an acre to the corn crop.

Black Clay Loam (420, 920, 1120)

Black Clay Loam, as mapped in Macon county, occupies 107.71 square miles, or about one-fifth of the total area of the county. This type includes at least three distinct types as it would now be mapped. These types cannot be so easily recognized in the field as those of the silt loam group just described, because there is little or no difference in their topographic occurrence. Their chief differences are in the character of the subsoil and lime content. No attempt will be made to describe each type individually, but in this general discussion the pronounced characteristics of each will be brought out. The surface soil is 9 to 12 inches thick and is a black clay loam. This is characteristic of all these types. The subsurface is 8 to 10 inches thick and ranges in color from a drabbish black to a brownish black with yellow spots. It is heavier than the surface soil but seldom compact. The upper subsoil varies considerably. In most of the small areas in the northeastern part of the county, the upper subsoil is grayish drab clay to about 32 inches; below that it becomes drabbish gray, a typical joint clay. In the flat area in the southeastern part of the county, the upper subsoil is a brownish drab clay, slightly compacted, and contains some gravel. The lower subsoil is more gravelly and is mottled with yellow. In the western part of the county the upper subsoil is brownish drab mottled with yellow, compact, and plastic. The lower subsoil is a drabbish yellow clay loam. The first two subsoils described are occasionally calcareous, and in places even the corresponding surface soils are calcareous.

Management.—When properly drained Black Clay Loam is a productive soil. The soil should be well tiled and sufficiently large outlets provided. It rarely needs limestone to grow sweet clover, and then only a small amount. Some of the calcareous areas above described contain sufficient alkali to be harmful. Unthrifty growth in these areas indicates the need of potash. This type of soil should receive regular additions of organic matter to maintain a favorable physical condition. Both stable manure and green manures should be used for this purpose. Clover should be grown every third or fourth year. The reader is referred to the summarized results of the Hartsburg experiment field which are found in the Supplement to this report, pages 64 and 65. The soil on this field is similar to Black Clay Loam as it occurs in Macon county.

Brown-Gray Silt Loam On Tight Clay (428, 928, 1128)

Brown-Gray Silt Loam On Tight Clay occurs in the northwestern part of the county and south of the town of Macon. It occupies a total of only 3.56 square miles in Macon county.

The surface soil is 6 to 7 inches thick and has a grayish brown color when dry, but may entirely lose the gray cast when moist. The thickness of the subsurface is variable, ranging between 12 and 18 inches. Its color is brownish gray to gray, and it sometimes has an ashy feel. Immediately below the gray subsurface is the plastic, compact, yellowish gray clay layer, the upper subsoil. This layer is 8 to 15 inches thick, and is almost impervious to water. Occasionally this tight layer is absent and the gray, ashy material continues down to a depth of 40 inches. The lower subsoil begins at depths of 36 to 42 inches and is a grayish yellow, friable silt loam. Numerous small, brownish-black, rounded iron pellets are found both on the surface and thru the soil. Small areas occur within the type in which large gray pellets or concretions of lime are found at or near the surface.

Management.—Drainage is one of the difficulties encountered in the management of this type. Surplus water must be removed by surface ditches and open furrows, as the tight subsoil makes tile ineffective except on those areas where the gray, ashy material extends down to a depth of 2½ feet or more. The soil is acid except in those areas in which lime concretions are found. Each field should be tested in detail with the assistance of the county farm adviser or the Agricultural Experiment Station before applying limestone, as this soil type varies from 0 to 3 or 4 tons in lime requirement per acre. The growing and plowing under of legume crops, especially sweet clover, and the addition of animal manure very materially improve the grain crops which follow. If satisfactory yields are not obtained after this procedure, a trial application of 75 pounds of some potassium fertilizer might be made. There is no experimental evidence to back up this recommendation so that only a trial should be made before fertilizing the entire field.

Brown Sandy Loam (460, 960, 1160)

Brown Sandy Loam is a very minor type in Macon county. It occurs principally as small areas adjacent to the Sangamon river valley in the western part of the county and occupies only 250 acres. Its topography and texture suggest that its material was blown up from the river bottom. The surface soil, to a depth of 6 to 7 inches, is a brown sandy loam. The subsurface is more sandy and is yellowish in color. The upper subsoil is a yellow sandy loam, slightly compact, enough so to keep the soil from being drouthy. The lower subsoil is a loose yellow sand.

Management.—The occurrence of this type in small areas within larger areas of Brown Silt Loam which have an intermediate topographic position makes it difficult to give it special treatment. It is recommended that this type be treated similarly to Brown Silt Loam except that special emphasis be given to increasing the organic-matter content by adding manure and by growing and plowing under green manures. The lime requirement is variable and the land should be tested before lime is applied.

UPLAND TIMBER SOILS

The upland timber soils are confined to narrow belts adjacent to the main streams, principally Sangamon river. They cover 65.88 square miles, slightly more than one-tenth of the total area of the county. The timber soils are characterized by a yellow or yellowish gray color which is due to their low organic-matter content. This lack of organic matter has been caused by the long-continued growth of forest trees. As the forests invaded the prairies, the following effects were produced: the shading of the trees prevented the growth of grasses, the roots of which are mainly responsible for the large amount of organic matter in the prairie soils; and the trees themselves added very little organic matter to the soil, for the leaves and branches either decayed or were destroyed by forest fires.

Yellow-Gray Silt Loam (434, 934, 1134)

Yellow-Gray Silt Loam as mapped occupies 45.27 square miles, forming the outer light-colored soil belt along streams. The character of the type varies with changes in topography and in the soil material from which it was formed. By far the larger portion is rather uniform and is described as follows. The surface soil is a brownish yellow silt loam about 6 inches thick. The subsurface is a grayish yellow silt loam about 9 to 12 inches thick. The upper subsoil begins at 15 to 18 inches and is a compact, slightly plastic, pale yellow clay loam, mottled with gray. On the more rolling areas it is less compact and more reddish. On the flatter areas it is more compact and grayish. The lower subsoil, below 32 to 36 inches, is a pale yellow silt loam, mottled with gray.

A few small areas south of the town of Antioch mapped as Yellow-Gray Silt Loam are rather flat. The surface soil in these flat areas is brownish gray and the subsurface is ashy gray. The upper subsoil is drabbish gray and very compact. In areas near streams where erosion has removed some of the silty covering, the gravelly drift forms the subsoil. These latter areas are not extensive since, when erosion starts, it soon removes all the loess covering and makes the area rough and hilly.

Management.—In the management of Yellow-Gray Silt Loam attention must be given to the topography on which it occurs as described above. The rolling areas have a pervious subsoil but are subject to erosion. Care should be taken to have vegetation growing on this land as much of the time as possible. There is little danger of erosion on the more gentle slopes but attention must be given to underdrainage, particularly to the flat areas whose subsoil is almost impervious. Surface ditching must be resorted to in these flat areas to remove the excess surface water. The type as a whole is acid but varies considerably in the amount of lime required to grow clovers. In general, 3 to 4 tons of limestone per acre must be spread before a satisfactory sweet clover or alfalfa stand can be obtained. The organic-matter content of this soil should be built up by the addition of animal and green manures plowed down. Altho there are no experiment field results on which to base fertilizer recommendations for this type of soil, it is suggested that a trial be made of one of the phosphates for wheat following the addition of organic matter.

Yellow Silt Loam (435, 935, 1135)

Yellow Silt Loam occupies 20.05 square miles and is found as the inner, light-colored soil belt along Sangamon river and its larger tributaries. It is a type produced by erosion and is rough and hilly. The character of the soil depends on the rapidity of the erosion; in protected places from which the timber has not been removed it resembles that of Yellow-Gray Silt Loam, and from this condition it varies thru all stages to one in which there is an entire absence of soil development. On these areas the sandy gravelly drift forms the surface. In other places the soil is shallow and friable and of a yellow or grayish yellow color.

Management.—Yellow Silt Loam should not be cultivated except where the slopes are not great and when proper attention can be given to controlling erosion. The less gullied areas can be used for permanent pasture or orchards while the remainder can be most profitably kept in permanent timber. Following an application of 1½ to 2 tons of limestone, sweet clover or alfalfa can be seeded on the less steep slopes. Alfalfa preceded by sweet clover usually makes a good stand and will remain on the land a number of years. An account of experiments in reclaiming badly eroded land of this soil type is given in the Supplement, page 65, under the Vienna field.

Yellow Sandy Loam (465, 965, 1165)

Yellow Sandy Loam is associated with Yellow Silt Loam and differs from it only in having received a coarse, sandy, wind-blown deposit from the adjacent bottom land. It occurs along Sangamon river and occupies only 307 acres in the county. The less sloping parts of it are well suited for alfalfa following liming.

Yellow-Gray Sandy Loam (464, 964, 1164)

Yellow-Gray Sandy Loam is a very minor type in Macon county, totaling only 51 acres. It is found in small areas near the Sangamon river bottom land. It is similar to Brown Sandy Loam excepting that it is lighter in color and is more acid. It may be handled in much the same manner, tho it requires more organic matter.

TERRACE SOILS

The terrace formations were made in remote times by overloaded and flooded streams which deposited an immense amount of material in the old channels. Later, as the streams diminished in size and cut their channels deeper, new bottom lands were developed, leaving the old flood plains above overflow, thus forming terraces. The terraces in Macon county were formed during or shortly after the advance of the Wisconsin glacier. They were later covered with a shallow deposit of wind-blown material similar to that of the uplands. All the terraces occur along Sangamon river. They occupy only 1.77 square miles.

Yellow-Gray Silt Loam Over Sand or Gravel (1536)

Yellow-Gray Silt Loam Over Sand or Gravel occupies 1.13 square miles and is found occurring in small areas between the upland and bottom land along Sangamon river. It differs little from Yellow-Gray Silt Loam, Upland, except in being somewhat better drained. See page 26 for a description of that type and for suggestions regarding its management.

Brown Silt Loam Over Sand or Gravel (1527)

Brown Silt Loam Over Sand or Gravel occurs along the south side of Sangamon river near the Sangamon county line. It covers only .61 square mile. The character of the soil resembles that of the second type described under Brown Silt Loam, Upland, except that it is more sandy. See page 22 for a description of that type and for suggestions regarding its management.

Brown Sandy Loam Over Sand or Gravel (1566)

There are only 19 acres of Brown Sandy Loam Over Sand or Gravel mapped in Macon county. It occurs in the larger area of Brown Silt Loam Over Sand or Gravel. See page 25 for a description and suggestions regarding the management of Brown Sandy Loam, Upland, which is similar to this terrace type.

SWAMP AND BOTTOM-LAND SOILS

The swamp and bottom-land soils in Macon county are found along the creeks and along Sangamon river. All of these soils are subject to overflow. There is a total of 20.05 square miles of bottom land mapped in Macon county, most of which is Sangamon river bottom land.

Mixed Loam (1454)

Mixed Loam, as its name implies, is very diverse in character. It is formed from deposits made during overflows. Its surface soil varies from a clay loam to a sandy loam, but is generally a silt loam of a sandy nature. The subsurface and subsoil vary as does the surface. No soil development has taken place as the material is too young and in many places is still being buried by a shallow deposit during each overflow. There are 14.31 square miles of Mixed Loam in the county.

Management.—The diversity of Mixed Loam prevents giving very specific recommendations for management. It will usually grow clover without lime and unless the land is subject to frequent overflow clovers should be grown and turned under to add organic matter. Corn is the chief crop grown on this land, and because the soil is frequently renewed, no fertilizer applications are needed.

Deep Brown Silt Loam (1426)

There are 5.70 square miles of Deep Brown Silt Loam mapped in the Sangamon river bottom land in the west part of the county. This area is more uniform in texture of the surface soil than is the remainder of the bottom land. It is a young, immature soil, productive, easily worked, and non-acid. The surface color is dark brown which frequently extends to a depth of 15 to 18 inches; below this the soil has a drabbish cast, becoming yellow at 30 to 40 inches. On the very flat areas where water stands, a gray color has developed below 20 inches. Deep Brown Silt Loam requires the same management as Mixed Loam because it is subject to frequent overflow.

Deep Peat (1401)

An area of 26 acres, forming part of the Lake Fork bottom land in Section 11, Township 18 North, Range 1 East, was originally mapped as Deep Peat. It is now largely decomposed into a muck. It is used for pasture and until better drainage is provided, it must continue to be uncultivated.

APPENDIX

EXPLANATIONS FOR INTERPRETING THE SOIL SURVEY

CLASSIFICATION OF SOILS

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

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

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

Soil Profile. The vertical section of the soil from the surface to the underlying unweathered material is called the soil profile. In a mature soil the profile is made up of a number of distinguishable layers or horizons.

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. For technical descriptions, soil scientists have adopted the designations *A*, *B*, and *C* for the principal horizons. Describable differences within an horizon are indicated by subscrip numbers, as A_1, A_2, B_1, B_2 and so on.

In this report the soil layers are described under the terms ''surface,'' ''subsurface,'' and ''subsoil.'' The surface and subsurface are embraced in the *A* horizon—the surface corresponding to the A_1 horizon and the subsurface to those lying below the A_1. The subsoil corresponds to the *B* horizon.

For a description of the surface, subsurface, and subsoil, see page 13.

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, whether level, rolling, hilly, or otherwise.

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

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

Not infrequently areas are encountered in which type characters are not distinctly developed or in which they show considerable variation. When these variations are considered to have sufficient significance, type separations are made wherever 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 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 this report in connection with the description of the particular soil types.

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

As a further step in systematizing the listing of the soils of Illinois, recognition is given to the location of the types with respect to the geological areas in which they occur. According to a geological survey made many years ago, the state has been divided into seventeen areas with respect to geological formation and, for the purposes of the soil survey, each of these areas has been assigned an index number. The names of the areas together with their general location and their respective 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 *Illinoian moraines,* including the moraines of the Illinoian glaciations
300 *Lower Illinoian glaciation,* formerly considered as covering nearly the south third of the state
400 *Middle Illinoian glaciation,* covering about a dozen counties in the west-central part of the state
500 *Upper Illinoian glaciation,* covering about fourteen counties northwest of the middle Illinoian glaciation
600 *Pre-Iowan glaciation,* but now believed to be part of the upper Illinoian
700 *Iowan glaciation,* lying in the central northern end of the state
800 *Deep loess areas,* including a zone a few miles wide along the Wabash, Illinois and Mississippi rivers
900 *Early Wisconsin moraines,* including the moraines of the early Wisconsin glaciation

1000 *Late Wisconsin moraines,* including the moraines of the late Wisconsin glaciation
1100 *Early Wisconsin glaciation,* covering the greater part of the northeast quarter of the state
1200 *Late Wisconsin glaciation,* lying in the northeast corner of the state
1300 *Old river-bottom and swamp lands,* formed by material derived from the Illinoian or older glaciations
1400 *Late river-bottom and swamp lands,* formed by material derived from the Wisconsin and Iowan glaciations
1500 *Terraces,* bench or second bottom lands, and gravel outwash plains
1600 *Lacustrine deposits,* formed by Lake Chicago, the enlarged glacial Lake Michigan

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

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

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

As a convenient means of designating types and their location with respect to the geological areas of the state, each type is given a number made up of a combination of the index numbers explained above. This number indicates the type and the geological area in which it occurs. The geological area is always indicated by the digits of the order of hundreds while the remainder 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 Illinoian 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 the last of November. 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.

FIG. 7.—EXAMINING THE SOIL PROFILE

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 in 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.

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 13.

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 micro-organisms. 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

At least ten of the chemical elements are known to be essential for the growth of the higher plants. These are *carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium,* and *iron.* Other elements are

Fig. 8.—All Essential Plant-Food Elements Must Be Present

The jars in which these corn plants are growing contain pure sand to which have been added various combinations of the essential plant-food elements. If a single one of these elements is omitted, the plants cannot develop; they die after the small supply stored in the seed becomes exhausted.

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

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

Produce: Kind	Produce: Amount	Nitrogen	Phosphorus	Sulfur	Potassium	Magnesium	Calcium	Iron
		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.

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 are dependent upon the soil for the other elements, and they also utilize the soil nitrogen so far as it becomes soluble and available during their period of growth.

The vast difference with respect to the supply of these essential plant-food elements in different soils is well brought out in the data of the Illinois soil survey. For example, it has been found that the nitrogen in the surface 6⅔ inches, which represents the plowed stratum, varies in amount from 180 pounds per acre to more than 35,000 pounds. In like manner the phosphorus content varies from about 320 to 4,900 pounds, and the potassium ranges from 1,530 to about 58,000 pounds. Similar variations are found in all of the other essential plant-food elements of the soil.

With these facts in mind it is easy to understand how a deficiency of one of these elements of plant food may become a limiting factor of crop production. When an element becomes so reduced in quantity as to become a limiting factor of production, then we must look for some outside source of supply. Table 6 is presented for the purpose of furnishing information regarding the quantity of some of the more important plant-food elements contained in materials most commonly used as sources of supply.

TABLE 6.—PLANT-FOOD ELEMENTS IN MANURE, ROUGH FEEDS, AND FERTILIZERS[1]

Material	Pounds of plant food per ton of material		
	Nitrogen	Phosphorus	Potassium
Fresh farm manure	10	2	8
Corn stover	16	2	17
Oat straw	12	2	21
Wheat straw	10	2	18
Clover hay	40	5	30
Cowpea hay	43	5	33
Alfalfa hay	50	4	24
Sweet clover (water-free basis)[2]	80	8	28
Dried blood	280	.....	.....
Sodium nitrate	310	.....	.....
Ammonium sulfate	400	.....	.....
Raw bone meal	80	180	.....
Steamed bone meal	20	250	.....
Raw rock phosphate	.....	250	.....
Acid phosphate	.....	125	.....
Potassium chlorid	.....	.....	850
Potassium sulfate	.....	.....	850
Kainit	.....	.....	200
Wood ashes[3] (unleached)	.....	10	100

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

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 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 nitrificataion and nitrogen fixation. It promotes sanitation of the soil by inhibiting the growth of certain fungous diseases, such as corn-root rot. Experience indicates that it modifies either directly or indirectly the physical structure of fine-textured soils, frequently to their great improvement. Thus, working in one or more of these different ways, limestone often becomes the key to the improvement of worn lands.

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

The Potassium Thiocyanate Test for Acidity. This test is made with a 4-percent solution of potassium thiocyanate in alcohol—4 grams of potassium thiocyanate in 100 cubic centimeters of 95-percent alcohol.[1] When a small quantity of soil shaken up in a test tube with this solution gives a red color the soil is acid and limestone should be applied. If the solution remains colorless the soil is not acid. An excess of water interferes with the reaction. The sample when tested, therefore, should be at least as dry as when the soil is in

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

good tillable condition. For a prompt reaction the temperature of the soil and solution should be not lower than that of comfortable working conditions (60° to 75° Fahrenheit).

The Hydrochloric Acid Test for Carbonates. Take a small representative sample of soil and pour upon it a few drops of hydrochloric (muriatic) acid, prepared by diluting the concentrated acid with an equal volume of water. The presence of limestone or some other carbonates will be shown by the appearance of gas bubbles within 2 or 3 minutes, producing foaming or effervescence. The absence of carbonates in a soil is not in itself evidence that the soil is acid or that limestone should be applied, but it indicates that the confirmatory potassium thiocyanate test should be carried out.

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

Fineness of Material.—The fineness to which limestone is ground is an important consideration in its use for soil improvement. Experiments indicate that a considerable range in this regard is permissible. Very fine grinding insures ready solubility, and thus promptness in action; but the finer the grinding the greater is the expense involved. A grinding, therefore, that furnishes not too large a proportion of coarser particles along with the finer, similar to that of the by-product material on the market, is to be recommended. Altho the exact proportions of coarse and fine material cannot be prescribed, it may be said that a limestone crushed so that the coarsest fragments will pass thru a screen of 4 to 10 meshes to the inch is satisfactory if the total product is used.

The Nitrogen Problem

The nitrogen problem is one of foremost importance in American agriculture. There are four reasons for this: nitrogen is becoming increasingly deficient in most soils; its cost when purchased on the open market is often prohibitive; it is removed from the soil in large amounts by crops; and it is readily lost from soils by leaching. A 50-bushel crop of corn requires about 75 pounds of nitrogen for its growth; and the loss of nitrogen from soils by leaching may vary from a few pounds to over one hundred pounds an acre in a year, 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 69 million pounds of atmospheric nitrogen. Leguminous plants such as clover are able, with the aid of certain bacteria, to draw upon the inexhaustible supply of air nitrogen, utilizing it in their food requirements. In so doing these leguminous plants, thru the decay of their own tissues, add to the soil nitrogen that has been taken from the air and transformed into food material that can be assimilated by other kinds of crops that follow.

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

Fig. 9.—Legumes Can Obtain Their Nitrogen From the Air

The photograph tells the story of how clover benefits the soil. In the pot at the left all the essential plant-food elements, including nitrogen, are supplied. In the middle jar all the elements, with the single exception of nitrogen, are present. At the right nitrogen is likewise withheld but the proper bacteria are supplied which enable the clover to secure nitrogen from the air.

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.

Different soil types display great variation in phosphorus content. In Illinois soils a range from 320 to 4,900 pounds an acre has been found in the surface 6⅔ inches, depending mainly on the origin of the soil.

The removal of phosphorus by continuous cropping slowly reduces the amount of this element 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 the use of 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 phosphorus-containing materials that are used as fertilizers. The more important of these are rock phosphate, superphosphate, bone meal, and basic slag.

Rock Phosphate.—Rock phosphate is a mineral substance found in vast deposits in certain regions. A good grade of the rock should contain 12 to 15 percent of the phosphorus element. The rock should be ground to a powder fine enough to pass thru a 100-mesh sieve, or even finer.

Superphosphate.—Superphosphate 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. By further processing, different concentrations are produced. The most common grades of superphosphate now on the market contain respectively 7, 8¾, and 10½ percent of the element phosphorus, and even more highly concentrated products containing as high as 21 percent are to be had. In fertilizer literature the term phosphorus is usually expressed as "phosphoric acid" (P_2O_5) rather than the element phosphorus (P), and the chemical relation between the two is such as to make the above figures correspond to 16, 20, 24, and 48 percent of phosphoric acid respectively. Besides phosphorus, superphosphate also contains sulfur, which is likewise an element of plant food. In general, phosphorus in superphosphate is considered to be more readily available for absorption by plants than that of raw rock phosphate.

Bone Meal.—Prepared from the bones of animals, bone meal appears on the market in two different forms, raw and steamed. Raw bone meal contains, besides the phosphorus, a considerable percentage of nitrogen. If the material is purchased only for the sake of the phosphorus, the cost of the nitrogen represents a useless expense. 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 and about 1 percent of the element nitrogen.

Basic Slag.—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 is a by-product in the manufacture of steel. It contains a considerable proportion of basic material and therefore tends to influence the soil reaction in the direction of reducing soil acidity.

Comparative Value of Different Forms of Phosphorus.—Obviously the carrier of phosphorus that gives the most economical returns, considered from all standpoints, is the best one to use. Altho this matter has been the subject of much discussion and investigation, the question remains unsettled. The fact probably is that there is no single carrier that will prove the most economical under all circumstances because so much depends upon soil conditions, crops grown, length of haul, and market conditions.

The relative cheapness of raw rock phosphate as compared with the treated material, superphosphate, makes it possible to apply for equal money expenditure considerably more phosphorus per acre in the form of rock than in the form of superphosphate, the ratio being, under present market conditions, roughly speaking 3½ to 1; that is to say, a dollar will purchase about three and a half times as much of the phosphorus element in the form of rock phosphate as in the form of superphosphate, and this is an important consideration if one is interested in building up a phosphorus reserve in the soil.

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 superphosphate 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, the silt loams and clay loams, are well stocked with potassium, altho it exists mainly in a very slowly soluble form. Many field experiments in various sections of Illinois during the past twenty-five years have shown little or no response to the application of potassium in the production of our common grain and hay crops. On the light-colored soils of southern Illinois, however, where stable manure has not been employed, potassium has been applied with profit, the benefit appearing mainly in the corn crop.

Peat soils are usually low in potassium content. It has frequently been demonstrated in field experiments that the difference between success and failure in raising crops on peat land depends on the use of a potash fertilizer.

Potassium has proved beneficial also on the so-called "alkali" spots occurring on certain soil types that are rather high in organic matter, including peat and very dark-colored sandy, silt, and clay loams. The potassium salts in this case appear to exert a corrective influence over what seems to be an unbalanced plant-food condition caused by an excess of nitrate in the soil.

Potassium fertilizer may be procured in the form of one of its salts, such as chlorid, sulfate, or carbonate of potassium, and any of these materials may be applied, where needed, at the rate of 50 to 150 pounds an acre, according to the method of distribution. For our most common crops about the only basis for choosing among these forms is the matter of price, taking into consideration the potassium content. Kainit is another substance containing potassium, but it is combined with magnesium in the form of a double salt. It is therefore less concentrated than the salts mentioned, and so should be applied in larger quantities. An application of about 200 pounds or more of kainit to the acre is suggested.

The Calcium and Magnesium Problem

When measured by crop removals of plant-food elements, calcium is often more limited in Illinois soils than is potassium, tho magnesium may occasionally be the low element. 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 upon a number of factors aside from those which have to do with climatic conditions. Among these factors may be mentioned the character of the soil, the kind of limestone, its condition of fineness, the amount present, and the sort of farming practiced. Because of this variation in the loss of lime materials from the soil, it is impossible to prescribe a fixed practice in their renewal that will apply universally. The tests for acidity and carbonates described above, together with the behavior of such lime-loving legumes as alfalfa and sweet clover, will serve as general indicators for the frequency of applying limestone and the amount to use on a given field.

Limestone has a direct value on some soils for the plant food which it supplies, in addition to its value in correcting soil acidity and in improving the physical condition of the soil. Ordinary limestone (abundant in the southern and western parts of Illinois) contains nearly 800 pounds of calcium per ton; while a good grade of dolomitic limestone (the more common limestone of northern Illinois) contains about 400 pounds of calcium and 300 pounds of magnesium per ton. Both of these elements are furnished in readily available form in ground dolomitic limestone.

The Sulfur Question

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

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

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

Physical Improvement of Soils

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

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

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

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

As a general principle, straw and cornstalks should be turned under, and not burned. Corn-borer control, however, may demand unusual measures, even to the burning of the stalks. There also 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 corn is planted. Whether the crop be 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 Rotation

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 crop rotation will prove best, 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 best adapted for building up poor soils.

On pages 46 and 47 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)
Fourth year —Clover
Fifth year —Wheat (with clover)
Sixth year —Clover, or clover and grass

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; 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.

The two following rotations are suggested as especially adapted for combating the corn borer:

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Corn (for silage)
Sixth year —Wheat (with sweet clover)

First year —Corn
Second year —Soybeans
Third year —Small grain (with legume)
Fourth year —Legume
Fifth year —Wheat (with alfalfa)
Sixth year —Alfalfa

Five-Year Rotations

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

First year —Corn
Second year —Soybeans
Third year —Corn
Fourth year —Wheat (with legume)
Fifth year —Legume

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 rotating over all fields if moved every six years.

Four-Year Rotations

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

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

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

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

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

Three-Year Rotations

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

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

Two-Year Rotations

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

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

It should be understood that in all of the above suggested cropping systems it may be desirable in some cases to substitute barley or rye for the oats or wheat. 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, or it may include alfalfa used as a biennial. The mixing of alfalfa with clover seed for a legume crop is a recommendable practice. In connection with livestock production it may be desirable to mix grass with the clover for pasture or hay. 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 Macon County)

The University of Illinois has conducted altogether about fifty soil experiment fields in different sections of the state and on various soil types. Altho some of these fields have been discontinued, the majority are still in operation. It is the present purpose to report the summarized results from certain of these fields located on soil types 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 forty 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 each crop represented every year.

Farming Systems

On most of the fields the treatment provides for two distinct systems of farming, livestock farming and grain farming.

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

In the grain system no animal manure is used. The organic matter and nitrogen are applied in the form of plant manures, including the plant residues produced, such as cornstalks, straw from wheat, oats, clover, etc., along with leguminous catch crops plowed under. It was the plan in this latter system to remove from the land, in the main, only the grain and seed produced, except in the case of alfalfa, that crop being harvested for hay the same as in the livestock system but certain modifications have been introduced in recent years, as explained in the descriptions of the respective fields.

Crop Rotations

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

Soil Treatment

The treatment applied to the plots at the beginning was usually standardized according to a rather definite system. With advancing experience, however, new problems arose calling for new experiments, so that on most of the fields plots have been divided and a portion given over to new systems of treatment, at the same time maintaining the original system essentially unchanged from the beginning.

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.—Limestone has usually been applied at the rate of 4 tons an acre as an initial application, and 2 tons an acre every four years thereafter until a considerable excess has accumulated in the soil. Rock phosphate has been applied at the rate of one ton an acre at the beginning, followed by an annual acre-rate of 500 pounds applied once in the rotation until a considerable excess has accumulated. Potassium has been applied usually in the form of 200 pounds of kainit a year. When kainit was not available, owing to conditions brought on by the World War, potassium carbonate was used.

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, (sP = superphosphate, bP = bone meal, rP = rock phosphate, slP = slag phosphate)
K = Potassium (usually in the form of kainit)
() = Parentheses enclosing figures, signifying tons of hay, as distinguished from bushels of seed

THE MT. MORRIS FIELD

The soil on the Mt. Morris experiment field, in Ogle county, represents fairly well the type Light Brown Silt Loam, described on page 22, altho the plots are not altogether uniform. This field was established in 1910. The plots considered here comprize four series under a rotation of corn, oats, clover, and wheat, with soil treatments as indicated in the accompanying table. The application of straw to the residues plots has been discontinued in these later years. In 1922 the application of limestone, and in 1923 the application of rock phosphate, were indefinitely suspended in order to observe the residual effect of these materials. The total quantity of limestone, applied since the beginning of the experiments averaged 7¾ tons an acre and the total amount of rock phosphate was 4 tons an acre.

FIG. 10.—CORN ON THE MT. MORRIS FIELD

The two pictures represent the extremes in corn production on this field. Where the untreated land has produced as a sixteen-year average 43.4 bushels an acre, the land under the residues, limestone, phosphate, potash treatment has yielded 67.2 bushels. The most profitable treatment, however, has been that of residues and limestone, which has produced 62.4 bushels.

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

TABLE 7.—MT. MORRIS FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields, 1913-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *14 crops*	Corn *16 crops*	Oats *16 crops*	Clover[1] *13 crops*	Soybeans *2 crops*
1	0	22.1	43.9	57.3	(1.79)	(1.56)
2	M	26.6	59.0	66.9	(2.34)	(1.70)
3	ML	32.8	64.7	70.7	(2.90)	(1.80)
4	MLP	34.2	64.3	71.5	(2.84)	(1.92)
5	0	22.1	43.4	53.9	(1.52)	(1.34)
6	R	24.2	50.5	58.0	(1.57)	(1.60)
7	RL	31.7	62.4	68.1	(2.07)	(1.89)
8	RLP	34.7	65.8	69.8	(2.09)	(2.07)
9	RLPK	35.2	67.2	70.6	(2.15)	(2.00)
10	0	22.9	43.0	51.7	(1.64)	(1.68)
	Crop Increases					
	M over 0	4.5	15.1	9.6	(.55)	(.14)
	R over 0	2.1	7.1	4.1	(.05)	(.26)
	ML over M	6.2	5.7	3.8	(.56)	(.10)
	RL over R	7.5	11.9	10.1	(.50)	(.29)
	MLP over ML	1.4	− .4	.8	−(.06)	(.12)
	RLP over RL	3.0	3.4	1.7	(.02)	(.18)
	RLPK over RLP	.5	1.4	.8	(.06)	−(.07)

[1] Including some seed evaluated as hay.

The outstanding results from these records are those produced by the manure treatment. Over 15 bushels of corn, over 9 bushels of oats, 4½ bushels of wheat, and a half ton of clover have been the average annual acre increases in crop yields from the manure plots over the corresponding checks. Residues alone have also produced increases in the crop yields altho the effect is much less pronounced than that of manure alone.

Limestone has been very profitably used in both the manure and residues systems but the benefit has been greater in the residues system.

The rock phosphate, as usual, has been somewhat more effective used with residues than with manure, but under present market conditions and used in the quantity employed in these experiments, it has thus far not returned its costs, even with residues. However, as noted above, applications of phosphate have been suspended and the residual effect of the accumulated phosphorus in the soil during the years to come will be awaited with interest.

No significant effect is apparent from potassium as used in these experiments.

THE DIXON FIELD

A summary of the results from the Dixon experiment field are presented here, inasmuch as the soil of this field is similar to some of that found in Macon county. (See discussion of Light Brown Silt Loam, page 22). This field includes about 21 acres and is laid out into two general systems of plots, a major and a minor system. The results from the major system will be considered here.

TABLE 8.—DIXON FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields, 1912-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *13 crops*	Corn *17 crops*	Oats *16 crops*	Barley *1 crop*	Clover[1] *10 crops*	Soybeans *5 crops*
1	0	19.9	36.9	48.1	43.3	(1.71)	(1.50)
2	M	26.3	57.8	61.4	46.4	(2.45)	(1.75)
3	ML	30.7	60.6	65.3	55.2	(2.70)	(1.87)
4	MLP	33.8	63.0	66.9	58.3	(2.83)	(1.91)
5	0	21.4	41.7	53.0	49.5	(1.41)	(1.27)
6	R	24.3	48.9	56.4	53.8	(1.49)	(1.43)
7	RL	27.7	56.4	61.1	54.5	(1.79)	(1.40)
8	RLP	32.0	57.8	63.4	59.0	(2.04)	(1.38)
9	RLPK	33.2	61.4	64.0	56.9	(2.21)	(1.42)
10	0	19.8	40.3	50.3	45.4	(1.81)	(1.46)
	Crop Increases						
	M over 0	6.4	20.9	13.3	3.1	(.74)	(.25)
	R over 0	2.9	7.2	3.4	4.3	(.08)	(.16)
	ML over M	4.4	2.8	3.9	8.8	(.25)	(.12)
	RL over R	3.4	7.5	4.7	.7	(.30)	−(.03)
	MLP over ML	3.1	2.4	1.6	3.1	(.13)	(.04)
	RLP over RL	4.3	1.4	2.3	4.5	(.25)	−(.02)
	RLPK over RLP	1.2	3.6	.6	−2.1	(.17)	(.04)

[1] Including some seed evaluated as hay.

FIG. 11.—CLOVER ON UNTREATED LAND, DIXON FIELD

A cutting of red-clover hay obtained from an untreated plot. Compare with the crop shown in Fig. 12.

The rotation practiced has been wheat, corn, oats, and clover. The treatment of the plots and management of the crops were, for the most part, maintained up to 1922 according to the general plan described on pages 48 and 49. The most important modification of the plan has been the discontinuance, within the last few years, of the applications of limestone, phosphate, and straw residues, after the total quantity of limestone applied had reached the average amount of 8 tons an acre and the total phosphate 4 tons an acre.

Table 8 gives a summary of the results in terms of the average annual crop yields obtained since the plots have been under complete treatment.

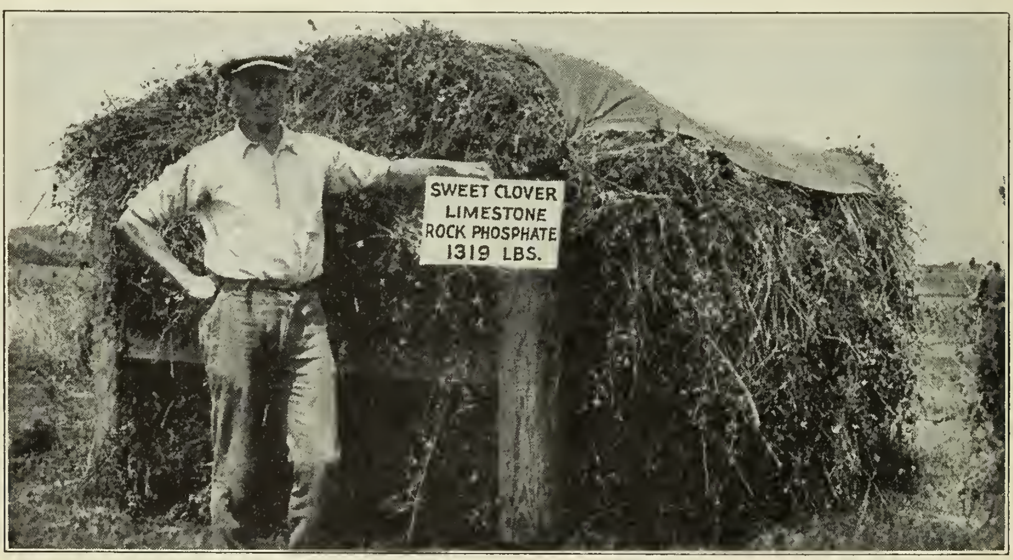


FIG. 12.—CLOVER ON TREATED LAND, DIXON FIELD

A cutting of red-clover hay produced under the residues, limestone, phosphate treatment. Here we have a yield of 1,319 pounds, more than two and one-third times the yield on the untreated land.

In considering these results, the most striking feature to be observed is the outstanding effect of farm manure. The average annual increase due to the use of manure alone has amounted to nearly 21 bushels of corn an acre, more than 13 bushels of oats, over 6 bushels of wheat, ¾ of a ton of clover, and ¼ of a ton of soybean hay.

Organic manure in the form of crop residues has also produced increases in yields altho not to the extent of those produced by animal manure.

Limestone in addition to organic manures has, with a single exception, effected more or less improvement. On the whole it has become increasingly profitable so that in the last rotation period it has returned a net profit per ton applied of $5.50 in the manure system and $7.00 in the residues system.

Rock phosphate, as usual, shows up to best advantage when used with residues on the wheat crop. The effect on other crops, however, has been such that the increases in yield are not sufficient to cover the cost of the application under existing market conditions.

Altho potassium has produced an average increase of 3.6 bushels an acre in corn, the effects on other crops are such as to render its use unprofitable in growing these common field crops.

THE KEWANEE FIELD

The Kewanee experiment field, located in Henry county, represents the soil type Brown Silt Loam, by far the most extensive type in Macon county. The matter of applying the results from this field to the Macon county areas is discussed on page 23.

This field has been in operation since 1915. It includes 20 acres of the dark-colored loessial soil characteristic of the region. Altho the main soil type represented is Brown Silt Loam, a detailed examination reveals the presence of a second type, Black Clay Loam On Drab Clay, occupying the basin of the draw which traverses the field in a winding direction. In topography the land is rather rolling and has a tendency to wash at certain spots. The field is laid out in two systems of plots designated as the major and the minor series. The major system is devoted to the regular series of tests and the minor to a special phosphate study.

The Major Series

A rotation system of wheat, corn, oats, and clover has been practiced on the major series, the crops being managed mainly as described on pages 48 and 49. Since 1921 the clover on the residues plots has been harvested for hay instead of seed and the oat straw has not been returned to the land. Since 1922 the periodic application of limestone has been suspended after the different series had received an average total of 6¾ tons to the acre, and no more is to be applied until it shall be needed again. The practice of returning the wheat straw has been discontinued since 1922, and since 1925 only one crop of clover hay on the residues plots has been removed, the second crop being plowed down as green manure. The phosphate applications were suspended in 1927 after evening up all phosphate plots to a total of 4 tons per acre.

TABLE 9.—KEWANEE FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1917-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat *10 crops*	Corn *12 crops*	Oats *12 crops*	Clover[1] *11 crops*
1	0	29.0	54.6	59.0	(1.64)
2	M	32.4	66.0	71.0	(2.23)
3	ML	35.2	70.6	73.2	(2.30)
4	MLP	40.0	72.1	72.4	(2.48)
5	0	30.3	56.1	60.6	(1.56)
6	R	31.6	58.2	59.6	(1.46)
7	RL	34.2	66.5	63.3	(1.71)
8	RLP	39.8	70.9	69.0	(1.89)
9	RLPK	40.6	74.4	70.6	(1.97)
10	0	28.1	50.3	56.4	(1.29)
	Crop Increases				
	M over 0	3.4	11.4	12.0	(.59)
	R over 0	1.3	2.1	− 1.0	−(.10)
	ML over M	2.8	4.6	2.2	(.07)
	RL over R	2.6	8.3	3.7	(.25)
	MLP over ML	4.8	1.5	− .8	(.18)
	RLP over RL	5.6	4.4	5.7	(.18)
	RLPK over RLP	.8	3.5	1.6	(.08)

[1]Including some seed evaluated as hay.

Table 9 gives a summary of the results showing the average annual yields for the different kinds of crops, including the years since the complete soil treatments have been in effect.

In looking over these results one may observe first the effect of animal manure, which has given profitable increases in all the crops. Residues alone show no significant effect.

Limestone in addition to manure has resulted in a small improvement, probably sufficient to cover the cost. It has been somewhat more effective in the grain system than in the livestock system.

Phosphorus, as usual, shows up in these averages to best advantage on the wheat crop in the residues system. Where used with manure and limestone, little effect was produced except on the wheat; but where used with residues and limestone, fair increases were produced in all crops, sufficient to return a financial profit under present market conditions. A study of the detailed data reveals a fact of interest in this connection which these averages do not bring out, and that is that the phosphate exerted very little influence during the earlier years of the experiments. Within the past seven or eight years, however, the phosphorus treatment has come suddenly into evidence and the trend of its effectiveness seems at present to be on the upgrade.

No significant response appears as the result of potassium fertilization, thus indicating the futility of purchasing potassium fertilizer for use in this kind of a cropping system on this kind of soil.

Comparative Phosphate Experiments

Four short series having only 4 plots each constitute the so-called minor system on the Kewanee field. These plots are now given over to a comparison of the effectiveness of rock phosphate and superphosphate.

Alfalfa was grown on these plots until 1922. In the beginning, limestone was applied to Plots 3 and 4 at the rate of 4 tons an acre. This application was repeated in 1919. In 1922 the present experiments with phosphates were begun and the same rotation practiced on the larger series described above was established on these series. In this comparison rock phosphate is used on Plots 1 and 3 at the annual rate of 400 pounds an acre, applied once in the rotation ahead of the wheat, but since 1927 rock phosphate has been applied at the same time as the superphosphate. Superphosphate is used on Plots 2 and 4 at the annual rate of 200 pounds an acre. It is applied twice in the rotation, one-half for wheat and one-half for oats. A summary of the annual crop yields and corresponding money values is given in Table 10.

TABLE 10.—KEWANEE FIELD: PHOSPHATE EXPERIMENT
Average Annual Crop Yields and Corresponding Money Values 1922-1928
Bushels or (tons) per acre

Soil treatment applied	Wheat *7 crops*	Corn *7 crops*	Oats *7 crops*	Legume hay *7 crops*	Value per acre
Residues, rock phosphate	43.3	74.1	76.5	(3.09)	$43.89
Residues, superphosphate	45.1	73.0	78.2	(3.02)	44.17
Residues, limestone, rock phosphate	38.8	73.0	73.5	(3.09)	42.05
Residues, limestone, superphosphate	46.6	75.1	77.0	(3.01)	44.83

In comparing these two forms of phosphate the following set of prices are assumed as representing the average market conditions for the past seven years (December 1 quotations): wheat, $1.21 a bushel; corn, 68 cents; oats, 39 cents; and hay, $13.90 a ton. For the cost of the phosphorus carriers, an estimate of $12 a ton for rock phosphate and $24 a ton for superphosphate may be taken, thus making the expense for the two kinds of phosphate equal.

With these prices applied to the yields given in Table 10, it is found that without limestone there is very little difference in value of crops produced under the two forms of phosphate. The 28 cents in favor of the superphosphate is scarcely significant in view of the experimental errors involved in this sort of test. In the presence of limestone the difference in crop values is $2.78 per acre per year in favor of superphosphate. Wheat has been the crop most affected by the form of phosphate applied.

It is to be borne in mind that the order of values can easily be shifted by a change in the relative yields of the respective crops or by a change in commodity prices. Furthermore no consideration has been given here to any possible difference in the residual effects of the two forms of phosphate which might appear upon discontinuing the treatments.

THE BLOOMINGTON FIELD

The experiments on the Bloomington field are of interest in connection with the management of Brown Silt Loam. This field is located in McLean county, northeast of the city of Bloomington. The work was started in 1902. Altho a fairly long period of years has been covered in these experiments, the field has only a single series of plots, so that only one kind of crop is represented each season. The crops employed have been corn, corn, oats, clover, and wheat; and, since 1905, they have been grown in the sequence named.

Commercial nitrogen applied in the form of dried blood was used in the early years up to 1905, when crop residues and clover were substituted. For 20 years all of the phosphorus on this field was applied in the form of steamed bone meal at the rate of 200 pounds an acre a year.

Table 11 presents a summary of the work to 1923 by average annual yields. The comparisons in the lower part of the table show the effect of the different plant-food materials in the various combinations in which they were applied.

The value of limestone on this field is difficult to assess on account of the erratic results found upon comparing Plots 1 and 2. Here both corn and wheat

TABLE 11.—BLOOMINGTON FIELD: SUMMARY OF CROP YIELDS
Average Annual Yields 1902-1923—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Corn *10 crops*	Oats *4 crops*	Wheat *4 crops*	Clover[1] *3 crops*
1	0	44.6	40.6	26.5	(.74)
2	L	41.5	44.7	24.1	(.80)
3	LR	47.5	46.2	27.9	(.88)
4	LbP	55.8	54.3	45.7	(2.54)
5	LK	46.2	43.5	25.5	(.90)
6	LRbP	60.6	66.0	49.7	(1.19)
7	LRK	48.6	46.8	27.5	(.82)
8	LbPK	60.9	57.2	44.5	(2.44)
9	LRbPK	64.2	63.1	50.4	(.81)
10	RbPK	58.8	52.8	49.3	(.83)
	Crop Increases				
	For limestone				
	L over 0	− 3.5	4.1	− 2.4	(.06)
	LRbPK over RbPK	5.4	10.3	1.1	−(.02)
	For residues				
	LR over L	6.0	1.5	3.8	(.08)
	LRbP over LbP	4.8	11.7	4.0	−(1.35)
	LRK over LK	2.4	3.3	2.0	−(.08)
	LRbPK over LbPK	3.3	5.9	5.9	−(1.63)
	For phosphorus				
	LbP over L	14.3	9.6	21.6	(1.74)
	LRbP over LR	13.1	19.8	21.8	(.31)
	LbPK over LK	14.7	13.7	19.0	(1.54)
	LRbPK over LRK	15.6	16.3	22.9	−(.01)
	For potassium				
	LK over L	4.7	− 1.2	1.4	(.10)
	LRK over LR	1.1	.6	− .4	−(.06)
	LbPK over LbP	5.1	2.9	− 1.2	−(.10)
	LRbPK over LRbP	3.6	− 2.9	.7	−(.38)

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

appear to have suffered from the application of limestone, but the difficulty may well be attributable to soil variability. Comparing Plots 9 and 10, it would appear that in combination with residues, phosphorus, and potassium, the limestone on the whole was beneficial.

The residues treatment, supplying organic matter and nitrogen, shows a beneficial effect on the grain crops, but not on the clover.

The prominent feature of the results on the Bloomington field is the effect of phosphorus. In all of the grain crops on every plot where bone meal was applied, there was a remarkable response to the treatment, as shown by the increases in yields. This response appears in all the combinations, even without the presence of residues, altho in combination with either residues or potassium the effect is accentuated. For example, comparing Plot 3 with Plot 6 (limestone and residues, with limestone, residues, and phosphorus) we find that the phosphorus treatment produced an average annual increase in the yield of corn of about 13 bushels an acre, while the yield of oats was increased by about 20 bushels, and that of wheat by about 22 bushels. Similar increases, tho not so pronounced, appear in comparing Plot 5 with Plot 8, where potassium instead of residues was present.

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

Thus it appears that on this field, under this system of farming, the lack of phosphorus is the outstanding limiting factor in production and the application of this element in the form of steamed bone meal is attended by a high financial profit.

New Phosphate Experiments

In view of this remarkable response to bone meal on the Bloomington field, it was of interest to know how other carriers of phosphorus would behave, and accordingly some experiments were planned to investigate this question. For this purpose, the plots were divided in 1924 and certain new treatments were applied in order to compare the effects of rock phosphate and of superphosphate with bone meal, and at the same time to determine the residual effect of the accumulated phosphorus resulting from the continuous application of the bone meal in presumably somewhat excessive amounts.

The following modifications of the original plots were introduced:

An extra plot, No. 11, was added to the series and all plots were divided into north and south halves. Residues, including cornstalks, the second crop of red clover, and other leguminous green manure crops are plowed down on all plots except Plot 1-S. Different phosphorus carriers are applied at the following acre-rates per rotation: bone meal, 1000 pounds, to Plots 2-N, 4-N, 6-N, 8-N, 9-N, and 10-N; rock phosphate, 2500 pounds, to Plots 3-N, 5-N, 7-N, and 11-N; superphosphate, 1000 pounds, to Plots 3-S, 5-S, 7-S, and 11-S. Two-fifths of the rotation application of these phosphates is made preceding the oats crop, two-fifths ahead of the wheat crop, and one-fifth in preparation for the corn crop.

Table 12 indicates the arrangement of these modified plots and also gives the results of the five years in which these later experiments have been in progress.

In arriving at the financial results presented in the table, the values of the crops are based upon December 1 farm price quotations for the years in which the respective crops were produced. In deducting the annual cost for the different treatments, the total amounts of materials applied during the entire period of operation on the field were prorated. The expense for limestone is reckoned here at $3 a ton, rock phosphate at $14, superphosphate at $28, bone meal at $48, and residues at 75 cents an acre.

It should be mentioned in considering the results that the soil of these plots is rather variable, with little provision for duplication; and also that some of the treatments are not now strictly comparable with one another on account of the previous history of the plots. Nevertheless, making allowances for these facts, certain figures in the last column of the table showing the net average acre value per year indicate effects worthy of consideration.

TABLE 12.—BLOOMINGTON FIELD: NEW PHOSPHATE EXPERIMENTS
Crop Yields and Values 1924-1928—Bushels or (tons) and dollars per acre

Plot No.	Soil treatment applied		1924	1925	1926	1927	1928	Average annual acre values		
	Previous	Present	Oats	Clover	Wheat	Corn	Corn	Gross	Cost of treatment	Net
1-N	0	R	60.6	(.79)	29.3	49.8	49.0	$29.29	$ .75	$28.54
1-S	0	0	58.4	(2.54)	19.5	41.0	33.4	28.82	......	28.82
2-N	L	RLP (bone)	72.6	(1.63)	35.0	58.6	52.2	36.18	6.55	29.63
2-S	L	RL	53.2	(.75)	18.7	46.0	35.2	23.41	1.75	21.66
3-N	RL	RLP (rock)	68.2	(2.18)	32.5	63.6	64.6	39.35	5.25	34.10
3-S	RL	RLP (super)	71.3	(1.74)	41.0	67.6	59.6	40.18	4.55	35.63
4-N	LP (bone)	RLP (bone)[1]	57.6	(1.81)	37.3	60.0	49.6	35.79	6.55	29.24
4-S	LP (bone)	RLP (bone)[2]	67.2	(1.89)	36.7	63.6	60.0	38.71	5.30	33.41
5-N	LK	RLKP (rock)	63.2	(1.66)	32.5	61.4	56.2	35.73	7.65	28.08
5-S	LK	RLKP (super)	78.4	(1.59)	40.7	69.4	55.6	39.99	6.95	33.04
6-N	RLP (bone)	RLP (bone)[1]	68.8	(2.18)	40.5	60.8	55.8	39.73	6.55	33.18
6-S	RLP (bone)	RLP (bone)[2]	71.6	(2.21)	40.0	64.2	60.4	41.09	5.30	35.79
7-N	RLK	RLKP (rock)	71.2	(2.11)	35.3	66.4	58.4	39.62	7.65	31.97
7-S	RLK	RLKP (super)	80.9	(1.66)	40.7	74.8	62.8	42.23	6.95	35.28
8-N	LKP (bone)	RLKP (bone)[1]	60.9	(1.69)	39.2	67.4	56.2	38.10	8.95	29.15
8-S	LKP (bone)	RLKP (bone)[2]	65.0	(1.59)	36.0	69.4	63.0	38.62	7.70	30.92
9-N	RLKP (bone)	RLKP (bone)[1]	60.9	(2.18)	43.8	75.8	60.4	42.56	8.95	33.61
9-S	RLKP (bone)	RLKP (bone)[2]	72.2	(1.65)	41.5	77.8	62.6	41.97	7.70	34.27
10-N	RKP (bone)	RKP (bone)[1]	48.2	(1.93)	45.7	56.6	51.2	37.02	7.95	29.07
10-S	RKP (bone)	RKP (bone)[2]	51.2	(1.53)	43.0	60.6	58.0	36.89	6.70	29.99
11-N	[3]	RP (rock)	70.4	(1.68)	45.3	61.8	47.4	38.43	4.25	34.18
11-S	[3]	RP (super)	60.0	(1.78)	44.5	63.0	57.2	39.11	3.55	35.56

[1]Bone meal applications omitted from 1917 to 1924. [2]No bone meal applied since 1917. [3]New plot added in 1924.

In answering the question as to whether other carriers of phosphorus would be as effective as the bone meal in building up this soil, attention is called to the results on Plots 2-N, 3-N, and 3-S where bone meal, rock phosphate, and superphosphate respectively have been employed in addition to limestone and residues. Unfortunately the comparison here is not altogether perfect in that the residues treatment on Plot 2-N was not introduced until 1924, whereas the other two plots had been under residues in the old system before the present experiments were begun and may, therefore, have an advantage in this respect over the bone-meal plot. However this may be, the results as they stand at present place both rock phosphate and superphosphate ahead of bone meal.

Between rock phosphate and superphosphate four direct comparisons in different combinations with other materials are afforded (Plots 3, 5, 7, and 11). In some years on some plots the results are in favor of superphosphate; in other years on the same plots the reverse is true. As the results stand at present, the majority are in favor of superphosphate but their inconsistency makes it difficult to come to any final conclusion. It may be noted that in these comparisons the two materials are not applied in amounts proportionate to equal cost as in other cases reported. Here 200 pounds per acre per year of superphosphate figured at $2.80 are applied against 500 pounds of rock phosphate valued at $3.50 per acre per year.

For light on the question of residual effect of accumulated phosphorus in the soil, attention is called to the results on Plots 4, 6, 8, 9, and 10, where the north half-plots are now regularly receiving bone meal, while the south halves have received none since 1917. Invariably the net return is higher on the south half, thus indicating that the reserve phosphate accumulated in the soil from previous applications is still exerting a beneficial effect that is more than adequate to offset the expense involved in renewed applications.

By way of a summary of the main lessons brought out at this time by the Bloomington experiments, the following statements may be made.

1. The results indicate an outstanding phosphorus hunger.

2. This phosphorus need is satisfied by the application of either bone meal, rock phosphate, or superphosphate.

3. There is a pronounced residual effect from previous excessive applications of phosphorus carried in the form of bone meal.

THE ALEDO FIELD

An experiment field representing the soil type Brown Silt Loam On Clay is located in Mercer county just west of Aledo. This field has been in operation since 1910. From its physical aspects this field should be well adapted to experimental work, the land being unusually uniform in topography and in soil profile.

There are two general systems of plots and they are designated as the major and the minor systems. The major system comprizes four series made up of 10 plots each. The plots were handled substantially as described for standard treatment until 1918, when it was planned to harvest the first crop of red clover on the residues plots for hay and to plow down the second crop if no seed were formed. In 1921 the return of the oat straw was discontinued. In 1923 the rotation was changed to one of corn, corn, oats and wheat. In this rotation it was planned to seed hubam clover in the oats on all plots, for use as hay or for soil improvement, and common sweet clover in the wheat on the residues plots for use as a green manure. Since this change, no residues except cornstalks and the green manure have been returned to the residues plots. The limestone applications were temporarily abandoned in 1923 after the different series had received 7½ to 9 tons an acre and no more will be applied until a need for lime appears. The phosphate applications were evened up to a total of 4 tons an acre in 1924, and no more will be applied for some time at least.

A summary of the results, showing the average annual yields obtained for the period beginning when complete soil treatment came into sway is given in Table 13. Comparisons in terms of crop increases, intended to indicate the effect of the different fertilizing materials applied is shown in the lower section of the table.

In looking over these results, one may observe first the beneficial effect of animal manure on all crops but especially on corn. This suggests the advisability of carefully conserving and regularly applying all stable manure. Residues alone have been beneficial for the second year corn but have shown little effect on the other crops of the rotation.

Where limestone has been applied, there is usually some increase in average yields, sufficient, at least, to cover the cost of the limestone.

TABLE 13.—ALEDO FIELD: SUMMARY OF CROP YIELDS
Average Annual Crop Yields 1912-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat	Corn	Oats	Clover	Soybeans[1]	Stubble clover: Sweet clover	Stubble clover: Hubam[2]
		14 crops	*23 crops*	*16 crops*	*6 crops*	*3 crops*	*2 crops*	*2 crops*
1	0	29.9	56.0	58.6	(2.21)	(1.60)	....	....
2	M	35.1	69.9	65.7	(2.74)	(1.63)	....	....
3	ML	35.5	73.5	68.5	(3.12)	(1.60)	....	(1.12)
4	MLP	37.2	74.7	69.5	(3.05)	(1.61)	....	(1.20)
5	0	31.0	58.0	60.0	(2.00)	(1.61)	....	....
6	R	31.8	64.5	61.5	(1.91)	(1.65)	....	....
7	RL	34.2	71.7	66.8	(1.79)	(1.88)	(1.57)	(.52)
8	RLP	37.9	74.1	68.3	(2.08)	(2.03)	(1.66)	(.80)
9	RLPK	37.8	75.4	70.7	(1.73)	(2.09)	(1.99)	(.57)
10	0	30.2	56.3	58.8	(2.38)	(1.62)	....	....
	Crop Increases							
	M over 0	5.2	13.9	7.1	(.53)	(.03)	....	....
	R over 0	.8	6.5	1.5	−(.09)	(.04)	....	....
	ML over M	.4	3.6	2.8	(.38)	−(.03)	....	(1.12)
	RL over R	2.4	7.2	5.3	−(.12)	(.23)	(1.57)	(.52)
	MLP over ML	1.7	1.2	1.0	−(.07)	(.01)	....	(.08)
	RLP over RL	3.7	2.4	1.5	(.29)	(.15)	(.09)	(.28)
	RLPK over RLP	− .1	1.3	2.4	−(.35)	(.06)	(.33)	−(.23)

[1]Soybeans all evaluated as hay, altho some plots were harvested as seed.
[2]Two crops hubam on Plots 3 and 4 but only 1 crop on 7, 8, and 9.

The addition of rock phosphate to the treatment has had very little effect in the manure system. Somewhat more favorable are the results in the residues system, but under present market conditions, the cost of rock phosphate applied in the manner of these experiments exceeds the value of the crop increase. However, the economic story has not all been told, for the application of lime and phosphate has been discontinued in order to observe the residual effects. The results of the next few years, therefore, will be awaited with great interest.

For the effect of potassium treatment Plots 8 and 9 should be compared. No significant response appears from this treatment so far as these common field crops show.

Special Phosphate Experiments

The so-called minor system of plots on the Aledo field is given over to a comparison of the effectiveness of different carriers of phosphorus.

In this experiment each series contains four plots. Plot 1 receives residues treatment only; Plot 2 receives residues and phosphorus in one of the forms under test; Plot 3 receives residues, limestone, and phosphorus; and Plot 4 is similar to Plot 3 with phosphorus omitted. On one series steamed bone meal is used as the carrier of phosphorus and is applied at the rate of 200 pounds per acre per year. On another series superphosphate is applied at the yearly rate of 333⅓ pounds per acre. On a third series rock phosphate serves as the source of phosphorus and is applied at the rate of 666⅔ pounds per acre per year. On the last series basic slag phosphate is applied at the rate of 250 pounds per acre per year.

The yields for all crops harvested on these plots are recorded in Table 14. Table 15, which is derived from Table 14, shows the value of the increase in crop yield presumed to have resulted from applying the various forms of phosphatic

TABLE 14.—ALEDO FIELD: PHOSPHATE EXPERIMENT
Annual Crop Yields—Bushels or (tons) per acre

Plot No.	Soil treatment applied	1916[1] Corn	1917[1] Oats	1918[1] Soybeans	1919 Wheat	1920 Corn	1921 Oats	1922 Clover hay	1923 Corn	1924 Corn	1925 Oats	1926 Wheat	1927 Corn	1928 Corn
501	R	53.4	85.5	18.9	32.4	72.8	48.9	(2.88)	83.5	58.2	63.9	44.0	33.9	69.8
502	RbP	61.7	91.7	19.0	34.7	86.4	61.9	(3.25)	82.7	66.0	75.0	59.2	63.2	71.7
503	RLbP	61.5	90.6	23.2	35.6	87.3	53.3	(3.48)	82.5	66.8	73.4	62.0	71.3	78.3
504	RL	55.1	80.5	22.6	32.9	77.7	47.7	(2.61)	88.2	60.3	64.5	44.6	58.5	72.0
601	R	55.2	84.7	19.5	33.0	71.2	53.6	(3.17)	84.7	57.3	64.4	43.3	37.2	71.3
602	RsP	57.8	87.7	18.7	38.3	87.1	60.9	(3.23)	82.5	65.9	76.1	60.6	54.8	73.2
603	RLsP	64.7	83.4	23.1	38.2	88.1	52.3	(3.53)	77.6	64.7	78.1	64.4	67.0	74.9
604	RL	51.9	81.7	24.6	32.8	84.9	50.2	(3.03)	84.1	51.9	64.1	47.3	60.8	74.4
701	R	54.3	83.1	20.8	34.2	75.6	52.8	(3.41)	82.8	61.2	66.6	44.8	39.9	72.3
702	RrP	58.8	83.3	23.3	36.7	80.4	63.0	(3.60)	87.8	69.3	70.3	59.2	61.8	74.3
703	RLrP	57.2	81.2	28.1	36.7	80.2	53.3	(3.82)	86.6	70.8	67.8	57.5	67.8	76.5
704	RL	52.1	81.7	26.9	34.1	82.0	48.9	(3.15)	84.6	62.5	66.3	48.8	63.0	74.6
801	R	57.6	73.8	18.0	33.7	68.1	54.8	(2.62)	74.3	58.8	45.0	45.8	42.2	70.4
802	RslP	56.4	87.8	20.6	38.1	81.0	66.2	(3.66)	80.0	69.1	66.3	60.2	60.7	69.3
803	RLslP	53.3	78.9	23.7	38.4	83.6	57.0	(3.63)	82.0	70.2	66.7	66.0	73.1	71.0
804	RL	51.8	77.5	21.8	33.3	70.4	59.8	(2.99)	82.6	59.9	53.9	48.2	60.4	75.1

[1]No residues.

fertilizers for the 13 crops harvested since the beginning of the applications up to 1928. In computing these comparisons, each phosphate plot is compared with its neighboring non-phosphate plot. Aside from the soybeans, the figures show without exception more or less crop increase on the phosphorus plots, no matter what the form of carrier employed.

The difficulty in arriving at a general conclusion regarding the comparative economy in the use of these different phosphorus materials is obvious, for all depends upon their relative cost, which fluctuates from time to time Furthermore, the prices received from farm produce likewise fluctuate; and to complicate matters still further, these fluctuations do not necessarily run parallel with those of the fertilizer cost. However, one may compute for himself the relative economy of producing these crop increases by applying any set of prices for crops and fertilizers which appear to be most applicable according to prevailing market conditions. For the purpose of furnishing an illustration of such a computation, the December 1 market quotations for the years in which the respective crops were actually produced have been applied to the results of these Aledo plots. The value of soybeans is arbitrarily set at $1.50 a bushel. For the cost of fertilizer materials the prices of phosphates are estimated as follows: bone meal, $40 a ton; superphosphate, $24; rock phosphate, $12; and slag phosphate, $20 a ton.

Reckoned on the basis of the above prices, it appears from the last column of Table 15 that slag phosphate has produced the most profitable returns of the four phosphorus carriers in the test, bringing an average profit of $4.89 an acre yearly where applied without limestone and $3.57 where applied with limestone.

TABLE 15.—ALEDO FIELD: PHOSPHATE EXPERIMENTS
Value of Crop Increases Produced by the Various Forms of Phosphate, Computed From Yields in Table 14

Comparison of treatments	Wheat *2 crops*	Corn *6 crops*	Oats *3 crops*	Clover *1 crop*	Soybeans *1 crop*	Total increase *13 crops*	Cost of phosphate *13 crops*	Profit from *13 crops*	Profit per acre per year
Bone meal, residues, *over* residues	$23.35	$44.04	$11.67	$ 4.63	$ .15	$83.83	$52.00	$31.83	$ 2.45
Bone meal, residues, lime, *over* residues, lime	26.90	27.01	11.31	10.88	.90	77.00	52.00	25.00	1.92
Superphosphate, residues, *over* residues	32.23	32.12	8.15	.75	− 1.20	72.05	52.00	20.05	1.54
Superphosphate, residues, lime, *over* residues, lime	32.20	25.33	6.62	5.88	− 2.25	67.77	52.00	15.77	1.21
Rock phosphate, residues, *over* residues	22.81	34.51	4.38	2.38	3.75	67.83	52.00	15.83	1.22
Rock phosphate, residues, lime, *over* residues, lime	16.07	17.15	1.49	8.38	1.80	44.89	52.00	− 7.11	− .55
Slag phosphate, residues, *over* residues	26.80	32.46	19.86	13.00	3.90	96.02	32.50	63.52	4.89
Slag phosphate, residues, lime *over* residues, lime	32.43	24.59	11.07	8.00	2.85	78.94	32.50	46.44	3.57

Bone meal has given an average profit of $2.45 applied without limestone and $1.92 applied with limestone. Superphosphate has returned $1.54 used without limestone and $1.21 used with limestone. Rock phosphate has produced a profit of $1.22 an acre a year when applied without limestone and a loss of 55 cents when used with limestone.

In considering these results, it may be pointed out that the quantities of phosphatic materials employed in these experiments are, with the possible exception of the slag phosphate, greater than ordinarily would be used, or need to be used, in good farm practice. Moreover, no consideration is given in these comparisons to the relative phosphorus reserves which should have accumulated in the soil. Finally, it should be emphasized that the order of these values might be easily shifted by relatively small change in commodity prices.

Limestone at the rate of 4 tons an acre was applied to Plots 3 and 4 in 1912 when the land was still under alfalfa, and another dressing was added in 1917 after the present experiments were under way. The results from the limestone treatment are shown in Table 16.

At the prices for produce and limestone assumed in these computations, a profit of $1.69 an acre a year for limestone applied without phosphate of any kind is found. Where limestone was applied with bone meal, the limestone profit was 99 cents an acre a year, and with superphosphate it was likewise 99 cents an acre. Used with rock phosphate, the crop increases were so small that there was a loss of 10 cents an acre a year. Applied with slag phosphate, the returns show a profit of 94 cents an acre a year.

TABLE 16.—ALEDO FIELD: PHOSPHATE EXPERIMENTS
Value of Crop Increases Produced by Limestone, Computed From Yields in Table 14

Comparison of treatment	Wheat *2 crops*	Corn *6 crops*	Oats *3 crops*	Clover *1 crop*	Soybeans *1 crop*	Total increase *13 crops*	Cost of limestone[1] *13 crops*	Profit from *13 crops*	Profit per acre per year
Limestone, residues, *over* residues	$3.25	$22.14	$−.40	$−.84	$7.01	$31.16	$9.18	$21.98	$1.69
Limestone, residues, bone meal, *over* residues, bone meal	5.31	11.35	−3.76	2.88	6.30	22.08	9.18	12.90	.99
Limestone, residues, superphosphate, *over* residues, superphosphate	4.43	11.93	−4.58	3.75	6.60	22.02	9.18	12.84	.99
Limestone, residues, rock phosphate, *over* residues, rock phosphate	−2.07	5.00	−5.04	2.75	7.20	7.84	9.18	− 1.34	− .10
Limestone, residues, slag phosphate, *over* residues, slag phosphate	7.71	11.26	−1.81	− .38	4.65	21.44	9.18	12.26	.94

[1]Owing to the fact that the first application of limestone on these plots was made for alfalfa four years before the present experiments were started, the total expense of $12 an acre for limestone is prorated, leaving a charge of $9.18 for the 13 crops involved in the present experiments.

It appears, therefore, that by distributing the cost of the limestone over the years since its first application, this material has returned a moderate profit except where used with rock phosphate.

It should be observed that the Aledo field represents one of those borderline cases, so to speak, in which the upper soil is nearly neutral or only slightly acid and the lime requirement, therefore, is not very marked. As time goes on, however, and cropping continues, a greater need for lime will probably develop. By discontinuing liming on these plots the annual cost of the limestone already applied is automatically reduced, so that net returns which hitherto have perhaps represented an actual loss may sooner or later result in a positive profit.

THE HARTSBURG FIELD

Black Clay Loam, as noted on page 24, occupies over 100 square miles in Macon county. The results of the Hartsburg field, situated in Logan county just east of the town of Hartsburg, are suggestive of the treatments that are effective on this type of soil.

The Hartsburg field was started in 1911. It is laid off in five series of 10 plots each. The crop rotation up to 1923 was wheat, corn, oats, and clover, with alfalfa growing on a fifth series.

The crops were handled mainly as described on pages 48 and 49 until 1918, when it was planned to remove one hay crop and one seed crop of clover from the residues plots. In 1921 it was decided to harvest all the clover as hay. At that

Table 17.—HARTSBURG FIELD: Summary of Crop Yields
Average Annual Yields 1913-1928—Bushels or (tons) per acre

Serial plot No.	Soil treatment applied	Wheat	Barley	Corn	Oats	Clover	Soy-beans	Alfalfa	Stubble clover	
									Hubam	Sweet clover
		13 crops	*1 crop*	*24 crops*	*17 crops*	*7 crops*	*2 crops*	*8 crops*	*1 crop*	*1 crop*
1	0....................	24.9	35.4	48.1	48.1	(1.84)	(1.29)	(3.47)	(.83)	....
2	M....................	29.2	44.2	58.8	52.9	(2.16)	(1.64)	(3.67)	(1.15)	....
3	ML..................	34.0	50.0	64.5	58.3	(2.32)	(1.82)	(3.91)	(.91)	....
4	MLP................	36.2	50.0	63.8	57.8	(2.39)	(1.92)	(4.19)	(1.17)	....
5	0....................	29.7	42.7	53.3	47.0	(1.28)	25.8	(3.33)	(.71)	....
6	R....................	32.7	47.5	63.7	53.3	(1.67)	26.8	(3.78)	(.75)	(.85)
7	RL..................	30.1	53.3	66.9	51.3	(1.64)	28.4	(3.45)	(.68)	(.75)
8	RLP................	34.3	46.9	67.3	55.4	(1.79)	26.1	(4.04)	(.72)	(.90)
9	RLPK..............	33.4	55.6	65.4	54.5	(1.70)	26.4	(4.16)	(.80)	(1.00)
10	0....................	30.5	45.8	52.8	48.0	(2.02)	(1.69)	(3.20)	(.75)	....

Crop Increases

	Wheat	Barley	Corn	Oats	Clover	Soy-beans	Alfalfa	Hubam	Sweet clover
M over 0............	4.3	8.8	10.7	4.8	(.32)	(.35)	(.20)	(.32)	....
R over 0............	3.0	4.8	10.4	6.3	(.39)	1.0	(.45)	(.04)	(.85)
ML over M.........	4.8	5.8	5.7	5.4	(.16)	(.18)	(.24)	–(.24)	....
RL over R..........	– 2.6	5.8	3.2	– 2.0	–(.03)	1.6	–(.33)	–(.07)	–(.10)
MLP over ML......	2.2	0.0	– .7	– .5	(.07)	(.10)	(.28)	(.26)	....
RLP over RL.......	4.2	– 6.4	.4	4.1	(.15)	– 2.3	(.59)	(.04)	(.15)
RLPK over RLP....	– .9	8.7	– 1.9	– .9	–(.09)	.3	(.12)	(.08)	(.10)

time the return of the oat straw to the land was discontinued. In 1922 the return of the wheat straw was likewise discontinued. The application of limestone was discontinued in 1922 after amounts ranging from 7½ to 10 tons an acre on the different series had been applied, and no more will be added until further need for it becomes apparent. In 1923 the phosphate applications were evened up to a total of 4 tons an acre on all phosphate plots, and no more will be applied for an indefinite period. At that time the rotation on the first four series was changed to corn, corn, oats, and wheat with a seeding of hubam clover in the oats on all plots, and a seeding of biennial sweet clover in the wheat on the residues plots. The rotation was changed also on the fifth series to corn, oats, wheat, and a mixture of alfalfa with red clover. The soil treatments are as indicated in Table 17, which summarizes by crops the yields for the period during which the plots have been under full treatment.

The outstanding feature of the results on the Hartsburg field is the large increases produced by organic manure whether in the form of crop residues or stable manure. The behavior of limestone is rather peculiar in that it has been more beneficial where applied with manure than where used with residues. Used with manure it shows some increase in practically all crops, while with residues its effect on several of the crops appears negative.

Altho rock phosphate has given some increases in wheat yield in both the manure and the residues systems, the results with other crops have been such as to render the use of this material unprofitable on this field. The addition of potassium appears to have produced no significant effect except on the one barley crop.

THE VIENNA FIELD

Macon county, as indicated in the descriptions of certain of its soil types, includes considerable land that is subject to destruction thru erosion or washing. Yellow Silt Loam, which occupies about 20 square miles in the county, is particularly susceptible to this kind of damage. Operators of land in Macon county will therefore be interested in experiments conducted on the Vienna field, in Johnson county, to test out different methods of reclaiming badly gullied land and preventing further erosion.

The Vienna field is representative of the sloping, erodible land so common in the extreme southern part of the state. When the experiments were started the whole field, with the exception of about three acres, had been abandoned because so much of the surface soil had washed away, and there were so many gullies that further cultivation was unprofitable. For the purpose of the experiments the field was divided into different sections (see Table 18). These were not entirely uniform; some parts were much more washed than others, and portions of the lower-lying land had been affected by soil material washed down from above. The higher land had a very low producing capacity; on many spots little or nothing would grow.

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

Fig. 13.—Proper Soil and Cropping Methods Would Have Prevented This Condition

This abandoned hillside is just over the fence from the field shown in Fig. 14. Yellow Silt Loam is particularly susceptible to this kind of damage.

Careful records were kept for nine years. The results, summarized in Table 18 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 on the check series (D). Wheat yielded 11.1 bushels on the protected series, in comparison with 4.6 bushels on the check, and clover yielded 4/5 of a ton on the protected series and but 1/5 of a ton on the check.

Table 18.—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)

Section A included the steepest part of the field and contained many gullies. The land was built up into terraces at vertical intervals of 5 feet. Near the edge of each terrace a small ditch was placed so that the water could be carried to a natural outlet without much washing.

Section B was used to test the so-called embankment method. Ridges were plowed up which were sufficiently high so that when there were heavy falls of rain the water would break over and run in a broad sheet rather than in narrow channels. At the steepest part of the slope, hillside ditches were made for carrying away the run-off.

Section C was washed badly but contained only small gullies. Here the attempt was made to prevent washing by incorporating organic matter in the soil and practicing deep contour plowing and contour planting. With two exceptions, about 8 loads of manure an acre were turned under each year for the corn crop.

Section D was washed to about the same extent as Section C. It was farmed in the most convenient way, without any special effort to prevent washing.

FIG. 14.—CORN GROWING ON AN IMPROVED HILLSIDE OF THE VIENNA EXPERIMENT FIELD

This land had formerly been badly eroded. It was reclaimed by proper soil treatment and cropping. Compare with Fig. 13.

Figs. 13 and 14 serve further to indicate what may be done with this type of soil even after it has become badly washed and gullied.

Altho these results show in principle the possibility of improving this land, it cannot be said that the experiments as conducted represent directly the most economical system of farming. 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.

Soil Reports Published

1 Clay, 1911
2 Moultrie, 1911
3 Hardin, 1912
4 Sangamon, 1912
5 LaSalle, 1913
6 Knox, 1913
7 McDonough, 1913
8 Bond, 1913
9 Lake, 1915
10 McLean, 1915
11 Pike, 1915
12 Winnebago, 1916
13 Kankakee, 1916
14 Tazewell, 1916
15 Edgar, 1917
16 DuPage, 1917
17 Kane, 1917
18 Champaign, 1918
19 Peoria, 1921
20 Bureau, 1921
21 McHenry, 1921
22 Iroquois, 1922
23 DeKalb, 1922
24 Adams, 1922
25 Livingston, 1923
26 Grundy, 1924
27 Hancock, 1924
28 Mason, 1924
29 Mercer, 1925
30 Johnson, 1925
31 Rock Island, 1925
32 Randolph, 1925
33 Saline, 1926
34 Marion, 1926
35 Will, 1926
36 Woodford, 1927
37 Lee, 1927
38 Ogle, 1927
39 Logan, 1927
40 Whiteside, 1928
41 Henry, 1928
42 Morgan, 1928
43 Douglas, 1929
44 Coles, 1929
45 Macon, 1929