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1923

# SOIL SURVEY OF IOWA FAYETTE COUNTY

AGRICULTURAL EXPERIMENT STATION  
IOWA STATE COLLEGE OF AGRICULTURE  
AND MECHANIC ARTS

Agronomy Section  
Soils



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no.30

Soil Survey Report No. 30  
March, 1923  
Ames, Iowa

# IOWA AGRICULTURAL EXPERIMENT

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Iowa Agricultural experiment station  
Soil survey of Iowa Fayette co.

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June, 1923

Soil Survey Report No. 30

# SOIL SURVEY OF IOWA

## Report No. 30—FAYETTE COUNTY SOILS

By W. H. Stevenson and P. E. Brown, with the assistance of L. W. Forman, H. J. Harper  
and H. W. Warner.



Typical farmstead in Fayette county.

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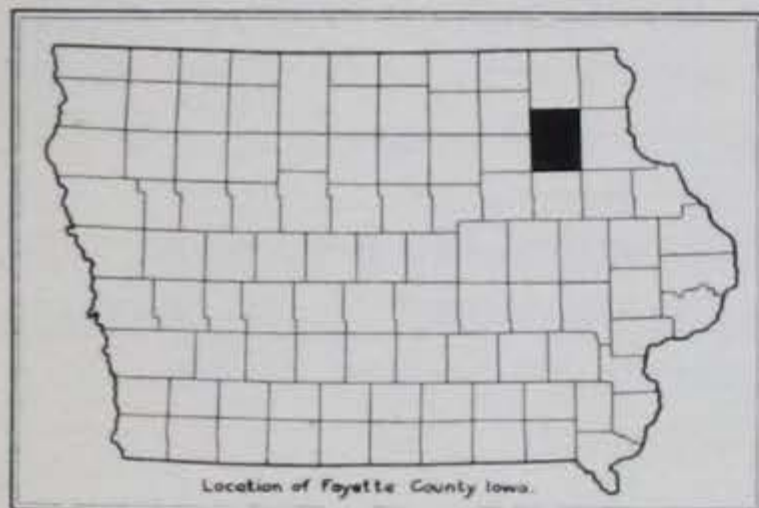
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# FAYETTE COUNTY SOILS\*

By W. H. Stevenson and P. E. Brown with the assistance of L. W. Forman, H. J. Harper and H. W. Warner

**F**AYETTE COUNTY is located in northeastern Iowa in the second tier of counties west of the Mississippi river and in the second tier south of the Minnesota state line. The location is shown in the accompanying sketch map. It lies partly in the Iowan drift soil area and partly in the Mississippi loess,



and hence the soils of the county are of loessial and glacial origin. The larger part of the county, however, slightly less than two-thirds of the total area is covered by drift soils.

The total area of Fayette county is 724 square miles or 463,360 acres. Of this area 435,996 acres or 94.0 percent is in farm land. The total number of farms is 3,224 and the average size of the farms is 135

acres. The following figures taken from the Iowa Yearbook of Agriculture for 1921 show the utilization of the farm land of the county:

Acres in general farm crops.....	263,470
Acres in pasture.....	158,535
Acres in farm buildings, feed lots and public highways.....	19,635
Acres in waste land.....	3,463
Acres in crops not otherwise listed.....	401

The type of agriculture most commonly practiced in Fayette county at the present time is general farming and includes chiefly cereal production with some dairying and some raising of hogs and other livestock. The dairy industry is increasing in importance and more attention is also being paid to other livestock. The raising of hogs is probably the most important livestock industry. There are a few herds of beef cattle and a few cattle are shipped in for feeding. There is some breeding of horses and, on a few farms, flocks of sheep are maintained. Poultry raising is becoming a more important industry and is adding much to the income of the farms. The type of farming seems to be gradually changing from the general system to the livestock system. Trucking is practiced on only a small area and fruit growing is likewise of little commercial importance in the county. There are, however, a few commercial orchards

There is a considerable area of waste land in the county and much of this might be reclaimed and made productive if proper methods of treatment were followed. The causes of unproductiveness are quite variable and hence no general recommendations for the treatment of these infertile areas can be given. Frequently drainage is the treatment needed and the installation of tile may make the land satisfactorily productive. In many cases, however, special methods of soil treatment must be practiced and in a later section of this report sug-

\*Soil survey of Fayette County, Iowa, by A. H. Meyer of the U. S. Department of Agriculture and H. J. Harper and H. W. Warner of the Iowa Agricultural Experiment Station.

TABLE I. ACREAGE, YIELD AND VALUE OF CROPS GROWN IN FAYETTE COUNTY, IOWA.\*

Crop	Acres	Percentage of total farm land of county	Bushels or tons per acre	Total bushels or tons	Average price	Total value of crops
Corn	104,000	23.85	44.0	4,576,000	\$ 0.30	\$1,372,800
Oats	85,000	19.49	24.0	2,040,000	0.23	469,200
Winter Wheat	300	0.06	10.0	3,000	0.90	2,700
Spring Wheat	890	0.20	10.0	8,900	0.87	7,743
Barley	3,500	0.80	22.0	77,000	0.42	32,340
Rye	380	0.08	15.0	5,700	0.73	4,161
Potatoes	1,590	0.36	22.0	34,980	1.40	48,972
Tame Hay	55,400	12.70	1.4	77,560	9.08	704,245
Wild Hay	12,400	2.84	0.94	11,656	7.47	87,070
Alfalfa	10	0.002	2.50	25	12.92	155
Pasture	158,535	36.36	...	.....	...	.....

gestions will be given as to the best methods of handling the individual soils. In special cases for more or less abnormal conditions, advice as to desirable treatments will be furnished upon request by the Soils Section of the Iowa Agricultural Experiment Station.

#### FAYETTE COUNTY'S CROPS

The general farm crops grown in Fayette county in the order of their importance are: corn, hay, oats, potatoes, barley, wheat, rye and alfalfa. The acreage, yields and value of these crops are given in table I.

Corn is the most important crop and provides the largest income. Average yields amount to 44 bushels per acre. Frequently larger yields are secured when the seasonal and soil conditions are more satisfactory. In 1921 almost one-fourth of the farm land of the county was utilized for this crop, and it is produced on practically all the soils. Probably the best yields are secured on the Tama silt loam. The White and Yellow Dent varieties and some Bloody Batcher are most commonly grown. About 85 percent of the corn produced is used for feed for hogs and cattle and the remainder is disposed of at the local elevators. About 7 percent is utilized for silage and in 1921 there were 828 silos in the county.

Hay is the second crop in value, the tame hay being grown on 12.7 percent of the total farm land of the county in 1921. Average yields of tame hay amount to 1.4 tons per acre. Clover and timothy mixed make up the most important hay crop. There is a small acreage in timothy alone and some clover is grown alone. Some other tame grasses are produced on small areas for hay and there is a rather considerable acreage devoted to the production of coarse forage (corn cut for forage, Kaffir, sorghum and root crops). Only a comparatively small area is in wild hay and the average yield is less than one ton per acre. Considerable timothy seed is produced and there is a small production of red clover seed also. About 80 percent of the hay grown is fed to work stock and cattle, the remainder being sold to outside markets.

Oats rank second in acreage and third in value. They are grown on 19.49 percent of the total farm land of the county with average yields of 24 bushels

\*Iowa Yearbook of Agriculture, 1921.

per acre. Much larger yields are secured under the most favorable seasonal and soil conditions. The early and medium early varieties are most commonly grown. About 75 percent of the crop is used for feed on the farms, the remainder being disposed of at the local elevators.

Potatoes are grown on a considerable area in the county with an average yield of 22 bushels in 1921. This is a low average and much larger yields are secured in favorable seasons. Usually enough potatoes are grown to supply the home demand but occasionally it is necessary to ship in from the outside markets and rarely is there any large sale of potatoes out of the county. Barley is produced to some extent in the county and gives average yields of 22 bushels per acre. About 50 percent of the barley produced is used for feeding purposes on the farms, the remainder being sold.

Wheat growing is not important in the county and only a small area is utilized for this crop. Yields are low and the value of the crop is small. There is a small area in rye but this crop likewise is of minor importance. Only a few acres are utilized for alfalfa but very satisfactory yields are secured when the soil is limed, and the crop is inoculated.

Other crops of minor importance in the county include flax, buckwheat, sorghum and Kaffir. Some sweet corn is grown for canning, particularly in the vicinity of Elgin, Stowell's Evergreen and Clark Early being the chief varieties. Average yields of sweet corn amount to 324 tons per acre. In the vicinity of West Union there is a small area devoted to cigar tobacco used chiefly for binder. Yields range from 1200 to 1600 pounds per acre and the crop proves very profitable. Some onions are grown on a commercial scale in the northeastern part of the county and there is some production of cantaloupes and water melons on some of the sandy soils. Vegetables are grown on small areas near the cities and towns to supply the local demand.

Small orchards of apples, plums, and pears are maintained on most farms. There are a few commercial orchards. Practically all of the fruit produced is utilized for home consumption. Small fruits, strawberries, blackberries and raspberries are grown to some extent and yield very satisfactorily. The production is rarely sufficient to supply the home demand.

FAYETTE COUNTY'S LIVESTOCK BUSINESS

The livestock industries include the raising and fattening of hogs, dairying, the raising and feeding of cattle, the raising of horses and the feeding of sheep. The following figures taken from the Iowa Yearbook of Agriculture for 1921 show the extent of the livestock industries of the county:

Horses, all ages.....	15,409
Mules, all ages.....	353
Swine, on farms July 1, 1921.....	113,096
Swine, on farms Jan. 1, 1922.....	72,059
Cattle, cows and heifers kept for milk.....	27,684
Cattle, other cattle not kept for milk.....	40,240
Cattle, all ages.....	67,924
Sheep, all ages on farms Jan. 1, 1922.....	6,621
Sheep, shipped in for feeding 1921.....	714
Sheep, total pounds of wool clipped.....	45,689
Poultry, total number on farms Jan. 1, 1922.....	447,436
Poultry, number dozen eggs received 1921.....	2,206,564

The raising of hogs is the most important livestock industry and the total number of hogs on the farms Jan. 1, 1922, was 72,059. From 30 to 40 hogs are fattened annually on nearly every farm and in some cases as many as 100 are fed. The leading breeds are Poland China, Duroc Jersey and Chester White. There are a few herds of Hampshire and Berkshire. The raising and feeding of hogs provides considerable income.

Dairying is an important industry and is gradually increasing. On the dairy farms the popular breed is the Holstein. There are, however, a few herds of Brown Swiss and Guernseys. A few dairy cows are kept on practically all farms and in most instances consist of grade Shorthorns. The cream produced is separated and delivered to creameries located in the towns and cities nearby. Considerable income is derived from the dairy industry.

In the northeastern part of the county there are some herds of beef cattle, chiefly Shorthorn, Hereford, Angus and a few herds of Red Poll. A few cattle are shipped in for feeding and on most farms a few head are fattened each year and sold.

Many farmers raise a few horses each year and occasionally have one or two for sale. Percheron, Belgian and Shire are the favorite breeds. Comparatively little attention is paid, however, to the breeding of farm and draft horses.

There are only a few flocks of sheep in the county, the Shropshire and Cotswold being the leading breeds. Sheep raising is of minor importance.

Poultry raising is receiving more attention and considerable income is being derived from the sale of poultry and poultry products.

#### VALUE AND CONDITION OF FAYETTE COUNTY LAND

The value of land in Fayette county is quite variable, depending on the location with reference to towns and railway facilities, the improvements on the farms, the topographic features and the natural soil conditions. At the time of the survey, 1919, the price of farm land ranged from \$50 to \$300 per acre. The better upland soils were held at the higher figure and would probably bring almost the same price now as that prevailing in 1919. The rough areas and bottomlands are held at the lower figures.

The average yields of general farm crops in Fayette county are fairly satisfactory but in many cases larger crops might be secured thru proper methods of handling the soils. In some instances the land is too wet and when that is true, the installation of tile is highly desirable and will bring about beneficial effects on crop growth.

Practically all of the soils are acid in reaction and if satisfactory crops, particularly of legumes, are to be secured, lime must be applied. It is very desirable that all soils in the county be tested for lime needs, and that application of this material be made at regular intervals to insure the best crop growth.

The supply of organic matter and nitrogen in most of the soils is not high and applications of fertilizing materials supplying these constituents are very desirable. Farm manure proves a particularly valuable fertilizer and crop residues and leguminous green manures should be utilized to supplement it, and to increase and maintain the content of organic matter and nitrogen. Farm manure is very effective even on those types which are not strikingly deficient in or-



ganic matter and on the light textured soils, large applications may be used profitably. On the heavier textured types which are not deficient, the smaller applications may be made with satisfactory results. There are many instances where leguminous green manures might be profitably employed as there is seldom a sufficient production of farm manure to keep all soils supplied.

The phosphorus content of Fayette county soils is low and phosphorus fertilizers will be necessary in the near future. There is evidence, however, that these materials may be employed with large returns at the present time. Whether rock phosphate or acid phosphate should be employed must be determined for individual farm conditions. Farmers are urged to test these two materials under their particular conditions and thus determine which material may be most profitably employed.

There is some serious erosion in Fayette county and several of the soils are considerably injured thru the washing action of water. The formation of gullies occurs in some of the rougher areas and may become a serious detriment to the proper utilization of the land. Sheet washing occurs to a considerable extent and is quite as injurious altho not so evident. Methods of preventing or controlling erosion should be practiced wherever it occurs and from among the methods suggested later in this report, some one may be chosen which will prove satisfactory for practically any condition.

## THE GEOLOGY OF FAYETTE COUNTY

The bed rock underlying the soils of Fayette county consists largely of limestone and shales. Only in a few instances is there any outcropping of these underlying rocks and then only in narrow ledges which are unimportant from the agricultural standpoint. There is one soil type, the Sogn clay loam which is derived from the underlying rock. It occurs only in a small area in the northeastern part of the county along the Clayton county line, covering an area of 1,856 acres. It is derived wholly or in part from a rock formation which is known as the Maquoketa shale.

With the exception of this one area the bed rock in Fayette county has been so completely covered by deposits of glacial drift and still later depositions of loess, that there is no effect on the soil conditions. At least three times during the glacial age great ice sheets swept over the county and upon their retreat left large deposits of debris or glacial till. The earliest of these glaciations is known as the pre-Kansan. This consisted of a greenish-blue or grayish-blue clay, filled with gravel and boulders. No soil type is derived even in part from this early deposit but it is evidenced in a few instances in railroad cuts. The later glaciations made such large deposits of till that the pre-Kansan material has no effect on the character of the soil types.

The second glaciation known as the Kansas extended over the entire surface of the county and the depth of the drift deposits left by this glacier is large everywhere except in the northeastern part of the county. It reaches a maximum thickness of 130 feet and varies widely from this depth, ranging to only a few feet in the northeastern part of the county. The Kansan drift material consists of a bluish clay containing numerous boulders of varying size. Where exposed to weathering the material has been oxidized to a reddish-brown color,

2 to 3 feet deep. Below this there is a yellowish boulder clay which merges into the unoxidized blue clay of the original drift material. None of the soil types have been wholly derived from this Kansan till as the later deposits have completely covered it. There are several instances where the later deposits have been so largely removed by erosion that the Kansan drift material makes up a part of the three-foot soil section and hence has a direct effect on the characteristics of the soil types.

At a number of points in the county, beds of Buchanan gravel are exposed. They vary from 3 or 4 feet to more than 20 feet in thickness, and occur along old valleys, lowlands, and in some upland areas. These deposits rest upon the Kansan drift material and are overlaid by the Iowan drift and the later loessial deposits. The third glaciation known as the Iowan covered nearly two-thirds of the area of the county. The northeastern portion was not invaded by this glacier. The debris or till left by the Iowan glacier is comparatively thin, ranging from 10 to 20 feet in depth. It consists of a yellow clay containing numerous boulders and coarse gravel. In several areas, the Iowan drift has been removed to such a large extent that the underlying Kansan drift appears in the three-foot section, and forms a part of the soil type. Thus the subsoil of some of the Thurston and Lindley soils is composed of the Kansan drift material. The major portion of the soils, however, are derived from the Iowan drift deposits, and are classified in the Carrington and Clyde series.

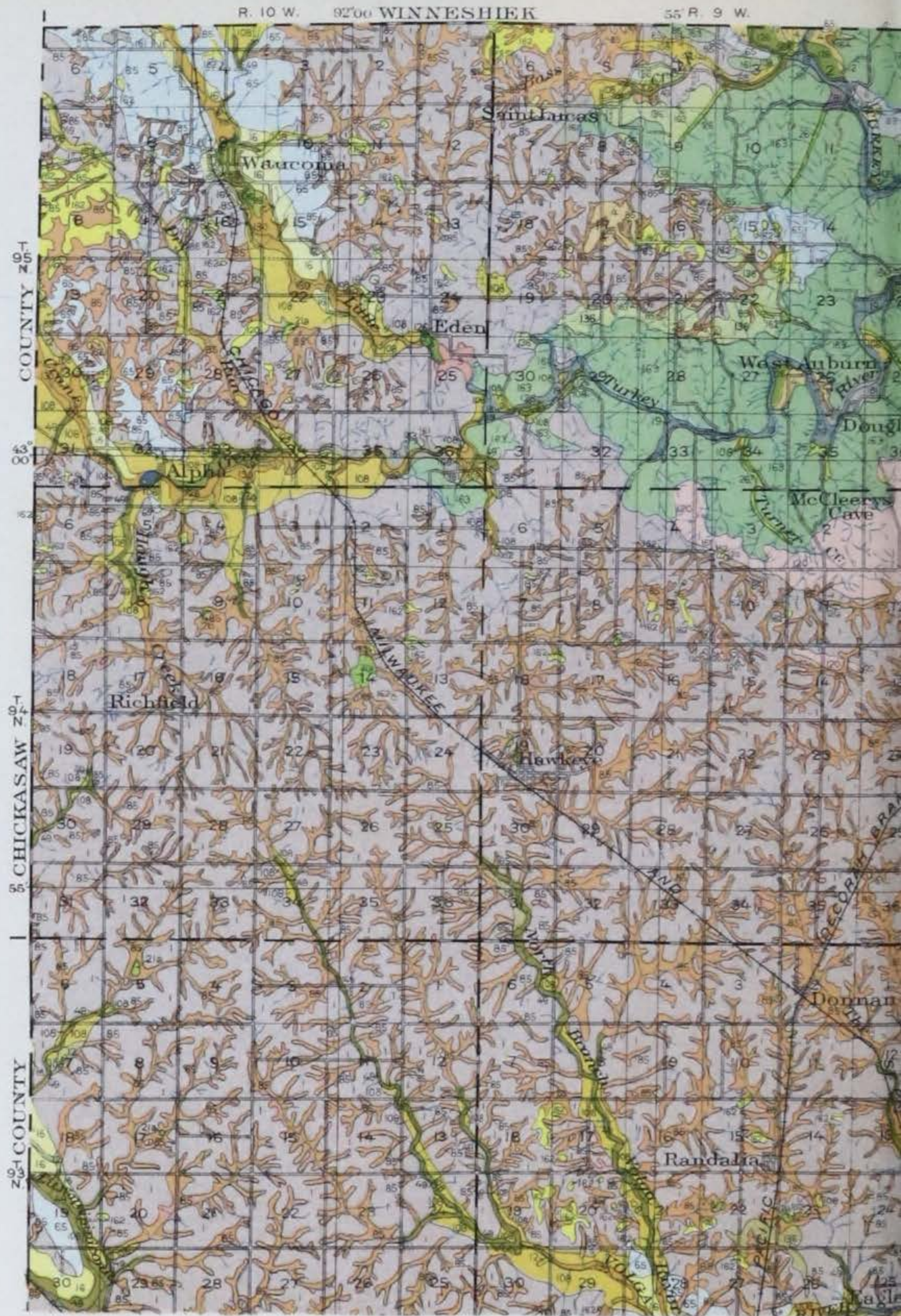
At a later date there was deposited over the drift materials in the northeastern part of the county a covering of finely divided silty materials known as loess. This deposit was made under climatic conditions which were very different from those prevailing at the present time. In its original unweathered condition it consists of a yellow, fine-grained silty material. It varies considerably in thickness, being deeper in the extreme eastern part of the county and thinning out somewhat towards the center where it meets the Iowan drift. Since its deposition the loessial material has been considerably modified thru the accumulation of plant remains, and the soils derived from the loess are much darker in color than the original material. The soil types mapped in the county which are of loessial origin are classified in the Tama and Fayette series. The Tama soils were formed under prairie conditions and are much darker in color, due to the larger accumulation of plant residues. The Fayette soils have been produced in timbered areas and are considerably lighter in color and contain less organic matter. About one-fourth of the total area of the county is now covered by loessial soils.

Terraces or second bottomlands are not extensively developed in Fayette county. They consist mainly of glacial terraces derived from the beds of Buchanan gravel and the Iowan gravels which are similar deposits laid down subsequent to the Iowan glaciation, and exposed along the Turkey and Little Turkey rivers. The higher terraces are classified in the O'Neill, Plainfield, Waukesha and Jackson series, the first two mentioned being characterized typically by layers of sand and gravel. The more recent terrace formations are mapped in the Bremer series. The soils in this series show less oxidation in the subsoil. The bottomland soils are formed from the loessial and glacial materials washed down from the uplands and they are subject to overflow and hence are

# SOIL MAP OF NOBLESBORO

U. S. DEPT. OF AGRICULTURE, BUREAU OF SOILS  
Milton Whitney, Chief. Curtis F. Marbut in charge Soil Survey

Thomas D. Rice  
Soils surveyed by A. H. Meyer  
in charge, and H. J. Harper and H. W.



## DRIFT SOILS

- Carrington loam
- Clyde silty clay loam
- Lindley loam
- Lindley sandy loam
- Lindley fine sandy loam
- Carrington sandy loam
- Thurston sandy loam

## LOESS SOILS

- Carrington fine sandy loam
- Fayette silt loam
- Tama silt loam

## TERRACE SOILS

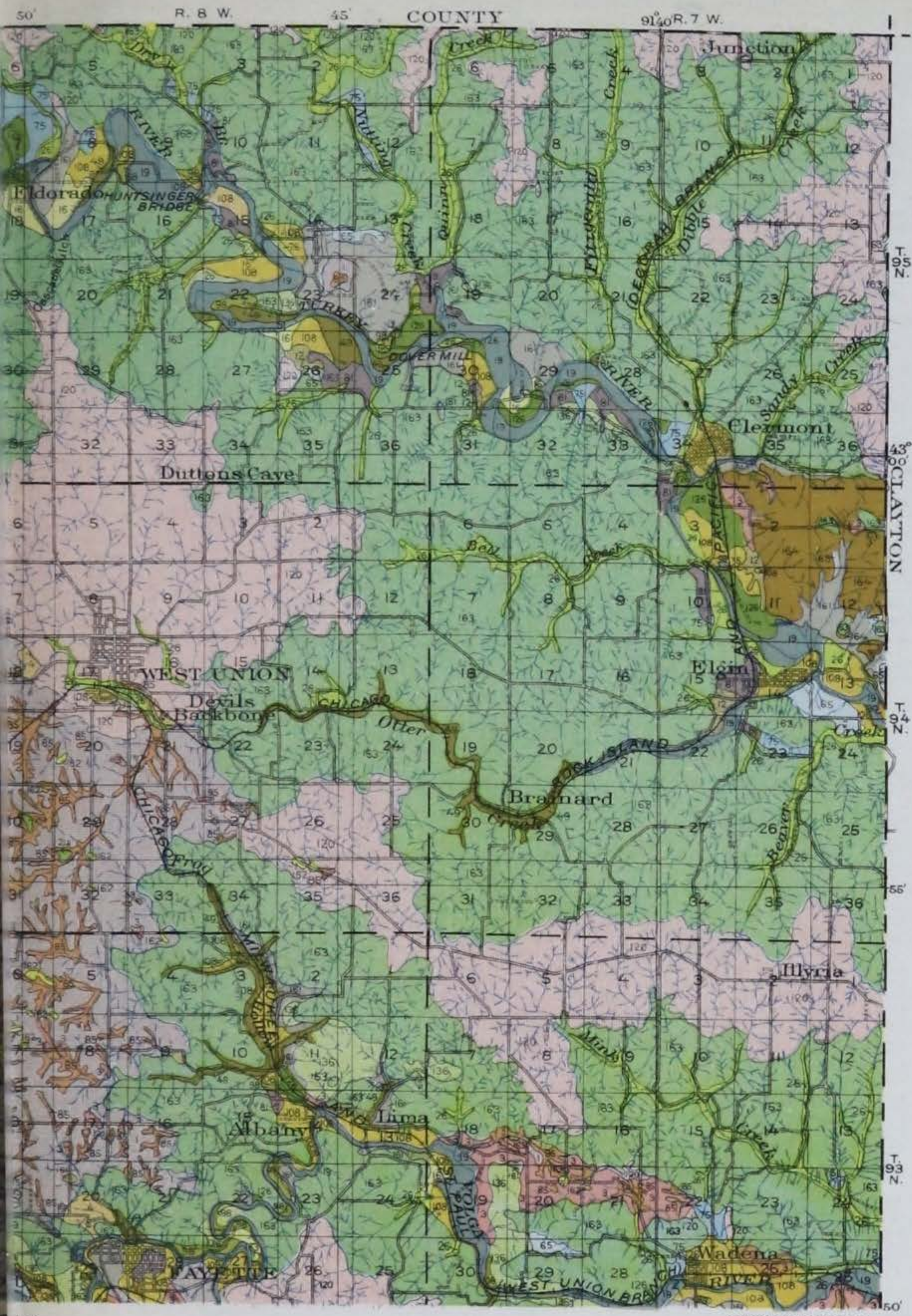
- O'Neill loam
- Plainfield loam

Scale: 1 inch

# YETTE COUNTY SHEET

Director, Northern Division,  
U. S. Department of Agriculture,  
Iowa Agricultural Experiment Station

IOWA AGRICULTURAL EXPERIMENT STATION  
C. F. Curtis, Director. W. H. Stevenson, in charge Soil Survey  
P. E. Brown, Associate in charge.



A. HOEN & CO BALTIMORE

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|---|---|
| <span style="background-color: #d9ead3; border: 1px solid black; padding: 2px;">12</span> Bremer loam           | <span style="background-color: #f4cccc; border: 1px solid black; padding: 2px;">49</span> Wabash loam           |
| <span style="background-color: #cfe2f3; border: 1px solid black; padding: 2px;">126</span> O'Neill sandy loam   | <span style="background-color: #fce4d6; border: 1px solid black; padding: 2px;">130</span> Cass fine sandy loam |
| <span style="background-color: #f4cccc; border: 1px solid black; padding: 2px;">98</span> Plainfield sandy loam | <span style="background-color: #cfe2f3; border: 1px solid black; padding: 2px;">19</span> Cass sandy loam       |
| <span style="background-color: #d9ead3; border: 1px solid black; padding: 2px;">81</span> Jackson silt loam     | <span style="background-color: #cfe2f3; border: 1px solid black; padding: 2px;">21*</span> Muck                 |
| <span style="background-color: #cfe2f3; border: 1px solid black; padding: 2px;">75</span> Waukesha silt loam    |   |
| RESIDUAL SOIL   |   |
| SWAMP AND BOTTOMLAND SOILS  |   |
| <span style="background-color: #d9ead3; border: 1px solid black; padding: 2px;">26</span> Wabash silt loam      | <span style="background-color: #f4cccc; border: 1px solid black; padding: 2px;">184</span> Sogn clay loam       |

constantly being modified in soil characteristics. These bottomland soils are classified in the Wabash and Cass series, and occur in relatively narrow areas along the more important rivers and creeks of the county.

#### PHYSIOGRAPHY AND DRAINAGE

There are two distinct topographical divisions apparent. Thruout the western and southern parts of the county where the soils are derived from glacial drift, the area consists of undulating prairie land. Extensive erosion has not occurred thruout this portion and in general the topography may be described as gently rolling to undulating. There are numerous small areas where the drainage is poor and wet marshy conditions have prevailed. In these spots the soil known as the Clyde silty clay loam has been mapped. This type occurs also in the areas along the intermittent drainageways and at the heads of the minor streams.

In general the slopes to the streams are gradual and the topographical features are not striking. In the extreme southwestern part, there is the broad glacial valley traversed by the Little Wapsipinicon river with a somewhat rougher topographic condition where the bottoms join the Lindley soils of the upland. A similar condition occurs along the southern part of Otter creek where it flows out of the county. There is likewise a rougher topographic condition along the Volga river in Center township, and in the northwestern township along Crane creek and Little Turkey river. In general these rougher areas are covered by the soils of the Lindley series and may be distinguished in this way on the map.

The second topographic division occurs in the northeastern corner and includes about one-fourth of the area. The various drainage channels thru this area have cut deeply into the loessial material and frequently thru the underlying Kansan drift into the underlying rock formation. The entire surface of this loessial area is therefore more rolling and the topographic features more pronounced than is the case in the drift area. The stream valleys are narrow and deeply cut. Erosion has been active and has left a rougher topographic condition where the uplands join the bottoms. Especially in those areas where the streams have cut thru to the underlying rock formations are the topographic features pronounced. The upland soils of this area in the Tama series are typically rolling to gently rolling in topography, while those areas covered by the Fayette soils are topographically steeply rolling to hilly or broken. Steep bluffs frequently occur along the streams where limestone beds occur while in other cases along the streams the slopes from the uplands are more gentle.

The second bottomlands occurring along the various streams of the county are flat in topography and lie from five to twenty-five feet above the flood plains of the streams. They are generally not eroded but there has been some modification of the higher terraces along Turkey and Little Turkey rivers, and the topography of some of these areas is somewhat rolling. The first bottomlands are level in topography and present few topographic differences.

The drainage of Fayette county is brought about by Turkey river, Maquoketa river and Wapsipinicon river, with their tributaries. Turkey river with its tributaries, Little Turkey river, Otter creek, and Volga river, brings about the

drainage of about three-fourths of the county. The chief tributaries of the Volga river, are Brush creek, Bear creek, Deep creek, Mink creek, Little Volga river, North Branch Volga river, Frog Hollow, and Coulee creek. These streams drain the entire central portion of the county. Turkey river and Otter creek with their tributaries, Beaver creek, Bell creek, Sandy creek, Dibble creek, Fitzgerald creek, Quinn creek, Nutting creek, Dry Branch, Turner creek, and Bass creek, drain the northeastern section. Little Turkey river, a tributary of Turkey river, with its tributaries, Crane creek, Dry Run, and Haugh creek

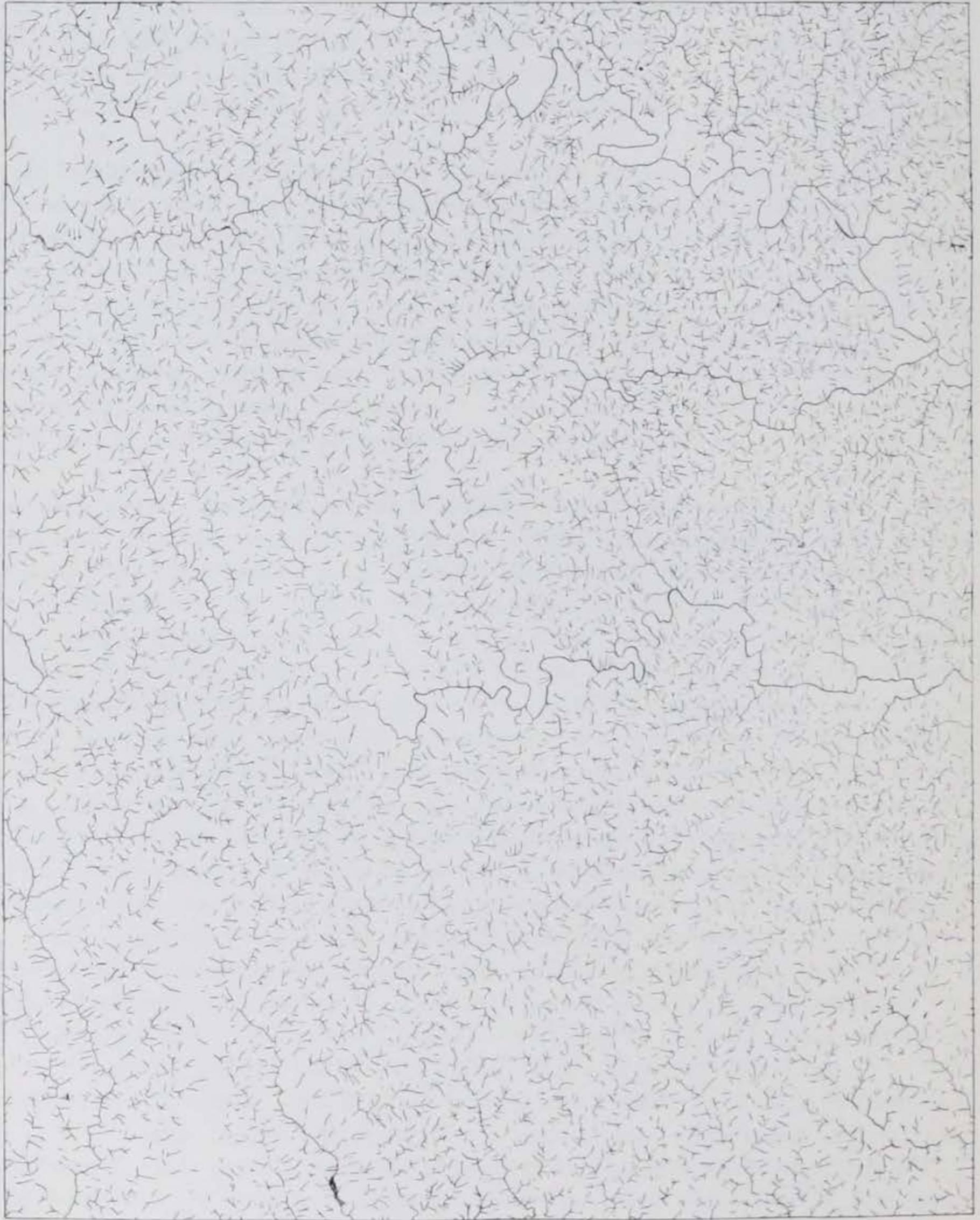


Fig. 1. Map showing natural drainage system of Fayette County.

drain the northwestern part. The Maquoketa river with its tributaries drains the southeastern corner, and the Wapsipinicon river with the chief tributaries the Little Wapsipinicon river and Otter creek, drains the southwestern part of the county.

In general, drainage conditions thruout Fayette county are fairly satisfactory, streams and intermittent drainage ways extending into all parts as is evidenced on the drainage map. There are many areas, however, where the installation of tile would be of large value. Thruout the entire drift area where the Clyde silty clay loam occurs so extensively cropping conditions would be improved by tiling. This soil type is characteristically poorly drained. Tiling out may be accomplished quite readily, and considerable areas may be made more productive thru proper drainage. The other upland soils in the county are generally quite satisfactorily drained and in only a few instances is tiling necessary. On the terraces the conditions necessary for the best crop production in the Bremer loam may be improved by tiling. Similar improvement may be brought about in the case of some of the bottom soils altho in the latter instance the soils are subject to overflow, and must be protected from flooding as well as drained, if crop growth is to prove satisfactory.

## THE SOILS OF FAYETTE COUNTY

The soils of Fayette county are grouped into five classes according to their origin and location, drift soils, loess soils, terrace soils, swamp and bottomland soils, and residual soils. Drift soils are formed from the materials carried by glaciers and left behind on the surface of the land when the glaciers retreated. They are quite variable in composition and contain pebbles and boulders. Loess soils are fine dust-like deposits made by the wind at some time when climatic conditions were quite different than at present. Terrace soils are old bottomlands which have been raised above overflow by a deepening of the river channel or a decrease in the volume of the streams which deposited them. Swamp and bottomland soils are those occurring in low, poorly drained areas, along streams, and subject to more or less frequent overflow. Residual soils are those which are formed from the underlying rock material and which remain resting upon it. The extent and occurrence of these groups of soils in Fayette county are shown in table II.

The largest portion of the county is covered by drift soils, 62.3 percent of the total area being in drift uplands. The loessial soils are second in extent and cover 27.3 percent of the total area. The terrace soils are much less extensive and cover 5.7 percent. The bottomland soils are still smaller in total area, covering 4.3 percent of the county. There is one small area of residual soil, amounting to 0.4 percent of the total area.

TABLE II. AREAS OF DIFFERENT GROUPS OF SOILS IN FAYETTE COUNTY.

Soil groups	Acres	Percent of total area of county
Drift soils	288,832	62.3
Loess soils	126,528	27.3
Terrace soils	26,368	5.7
Swamp and bottomland soils	19,776	4.3
Residual soil	1,856	0.4
	463,360	....

TABLE III. AREAS OF DIFFERENT SOIL TYPES IN FAYETTE COUNTY, IOWA.

Soil No.	Soil type	Acres	Percent of total area of county
DRIFT SOILS			
1	Carrington loam	195,264	42.1
85	Clyde silty clay loam	71,360	15.4
65	Lindley loam	8,000	1.7
161	Lindley sandy loam	4,608	1.0
136	Lindley fine sandy loam	3,712	0.8
3	Carrington sandy loam	2,688	0.6
162	Thurston sandy loam	2,176	0.5
4	Carrington fine sandy loam	1,024	0.2
LOESS SOILS			
163	Fayette silt loam	94,208	20.3
120	Tama silt loam	32,320	7.0
TERRACE SOILS			
108	O'Neill loam	14,976	3.2
16	Plainfield loam	4,544	1.0
12	Bremer loam	1,792	0.4
126	O'Neill sandy loam	1,664	0.4
98	Plainfield sandy loam	1,344	0.3
81	Jackson silt loam	1,024	0.2
75	Waukesha silt loam	1,024	0.2
SWAMP AND BOTTOMLAND SOILS			
26	Wabash silt loam	6,208	1.3
49	Wabash loam	5,376	1.1
130	Cass fine sandy loam	4,032	0.9
19	Cass sandy loam	3,968	0.9
21a	Muck	192	0.1
RESIDUAL SOIL			
164	Sogn clay loam	1,856	0.4
Total.....		463,360	

There are 22 soil types and an area of muck, making a total of 23 separate soil areas. There are 8 drift soils, 2 loess soils, 7 terrace types, 4 bottomland soils, and an area of muck, and one residual type. The areas of the different soil types are shown in table III.

The Carrington loam is the largest individual soil type in the county, covering 42.1 percent, almost one-half, of the total area. The Fayette silt loam is the second largest type, covering 20.3 percent of the total area. It is the largest of the loess soils. The Clyde silty clay loam is the second largest drift soil and the third most extensive type, covering 15.4 percent of the total area. The Tama silt loam is the second largest loess soil and the fourth largest type in the county, covering 7.0 percent of the total area. The O'Neill loam is the largest terrace type and covers 3.2 percent of the total area. The Lindley loam, the third largest drift soil, and the sixth largest type, covers 1.7 percent of the total area. The remainder of the drift soils are small in area, covering 1 percent, or less than 1 percent of the total area of the county. All the terrace types except the O'Neill loam mentioned above, are small in area, and cover 1 percent or less than 1 percent of the total area. The bottomland soils are all minor in area, the Wabash silt loam, the largest, covering 1.3 percent and the Wabash loam covering 1.1 percent of the county. The remaining types cover less than 1 percent of the total area.

The topographic features of the upland soils are directly related to the soil types. The Carrington soils are characterized by a rolling topography, and the



Clyde soils by a level to depressed topographic condition. The Lindley soils and the Thurston soils are generally rougher and more striking in topographic features. The Tama soils are gently rolling to undulating while the Fayette soils are strongly rolling to broken in topography. The terrace and bottomland soils are usually somewhat level in topography, occasionally, however, on the second bottoms erosion has occurred to some extent and the topography of the soils is gently rolling. This is the case in the Jackson and often in the Waukesha soils. The Sogn clay loam, the only residual soil, is quite level in topography. As has been noted earlier, those types which are level to flat in topography are generally in need of drainage and in Fayette county the need for drainage is evidenced particularly in the Clyde silty clay loam, the Bremer loam, and the Wabash soils on the bottoms.

### THE FERTILITY IN FAYETTE COUNTY SOILS

Samples were taken for analyses from each of the soil types in Fayette county. The area of muck was not sampled as it is small in extent and unimportant agriculturally. Furthermore the composition of all muck is much the same and many analyses of this material have been made. The more extensive soil types were sampled in triplicate but only one sample was taken in the case of the minor types. All samplings were made with the greatest care so that the results should be representative of the particular soil types, and to avoid variations due to abnormal local conditions, or previous soil treatments. The samples were secured at three depths, 0-6 2/3", 6 2/3"-20", 20"-40", representing the surface soil, the subsurface soil, and the subsoil respectively.

Analyses were made for total phosphorus, total nitrogen, total organic carbon, total inorganic carbon and the limestone requirement. The official methods were employed in the phosphorus, nitrogen and carbon determinations, and the Truog qualitative method was followed for the determination of lime requirement. The figures given in the tables are the averages of the results of duplicate determinations on all samples of each type, and they represent therefore, the averages of four or twelve determinations.

#### THE SURFACE SOILS

The results of the analyses of the surface soils are given in table IV. They are calculated on the basis of 2,000,000 pounds of surface soil per acre.

The phosphorus content of the various soils in the county is extremely variable, ranging from 485 pounds per acre in the Lindley fine sandy loam, up to 1,913 pounds in the Wabash loam. There is no evidence of any relationship between the phosphorus content of the soils and the various soil groups, except that the average of the bottomland soils seems to be somewhat higher than the average of the upland types. The terrace soils also average somewhat higher than the uplands. These comparisons might be expected, inasmuch as crop growth has been less on the bottomland and hence there has been less removal of phosphorus. The variations within groups are, however, more striking than the variations between groups.

There seems to be some relationship between the soil series and the phosphorus content, thus among the drift soils the Lindley soils are low in phosphorus, the Clyde soils are high and the Carrington types occupy an intermediate position

TABLE IV. PLANT FOOD IN FAYETTE COUNTY, IOWA, SOILS. POUNDS PER ACRE OF TWO MILLION POUNDS OF SURFACE SOILS (0-6 2/3")

Soil No.	Soil Type	Total Phosphorus	Total Nitrogen	Total Organic Carbon	Total Inorganic Carbon	Lime-n requirement
DRIFT SOILS						
1	Carrington loam	1,073	4,640	53,814	0	6,333
85	Clyde silty clay loam	1,603	8,150	90,745	0	3,500
65	Lindley loam	754	1,740	23,478	0	3,000
161	Lindley sandy loam	687	940	12,175	0	3,000
136	Lindley fine sandy loam	485	1,120	13,377	0	2,000
3	Carrington sandy loam	741	2,280	24,570	0	5,000
162	Thurston sandy loam	1,003	1,150	21,391	0	1,000
4	Carrington fine sandy loam	741	2,020	28,665	0	5,000
LOESS SOILS						
163	Fayette silt loam	653	1,760	20,885	0	2,500
120	Tama silt loam	849	3,360	45,318	0	5,000
TERRACE SOILS						
108	O'Neill loam	1,139	3,310	33,770	0	5,500
16	Plainfield loam	808	1,400	21,294	0	3,000
12	Bremer loam	1,684	6,240	76,767	0	8,000
126	O'Neill sandy loam	876	1,460	25,880	0	6,000
98	Plainfield sandy loam	808	1,340	23,641	0	3,000
81	Jackson silt loam	1,293	2,860	36,745	0	2,000
75	Waukesha silt loam	983	3,640	42,970	0	6,000
SWAMP AND BOTTOMLAND SOILS						
26	Wabash silt loam	1,669	4,200	53,631	0	1,000
49	Wabash loam	1,913	9,620	113,677	0	5,000
130	Cass fine sandy loam	808	1,800	27,237	1,100	0
19	Cass sandy loam	1,010	1,120	19,929	0	8,000
RESIDUAL SOIL						
164	Sogn clay loam	1,482	6,550	73,477	2,690	0

This is a relationship dependent to some extent upon the topographic position of the types. The level poorly drained Clyde soils are high in phosphorus while the rough, eroded Lindley soils are low. The Tama silt loam of the loessial upland is higher than the Fayette, and again there is evidence of an effect of topographic position, method of formation of the soil, and general soil series characteristics, on the phosphorus content. On the terraces the Bremer soils are the highest in phosphorus while many of the O'Neill types are low. The Waukesha and Jackson soils are somewhat intermediate and the Plainfield soils are generally low. On the bottoms the Wabash soils are richer than the Cass, which is undoubtedly a result of the difference in subsoil characteristics.

Some comparisons may also be made between soils of different texture which are mapped in the same series, thus the Carrington fine sandy loam and sandy loam are lower than the loam, the Lindley fine sandy loam and sandy loam are lower than the loam, the O'Neill sandy loam is lower than O'Neill loam, and the Cass fine sandy loam is lower than the sandy loam. It seems from these comparisons that the sandier textured soils contain less phosphorus than the finer textured types, at least when soils of the same series are compared. No comparisons are possible in the case of the heavier textured soils as so few heavy textured types are mapped. In general, however, conclusions reached in other counties are, that the heavier textured soils are richer in plant food constituents than the

coarse textured types. The Wabash loam in this county seems to be somewhat higher than the silt loam which is contrary to the usual results. Bottomland soils are so variable that conclusions from their analyses are difficult, and apparently the Wabash loam in this county, or at least the sample analyzed, was somewhat abnormal. The Sogn clay loam shows an average content of phosphorus but cannot be compared with other types because of its different texture. It seems to be somewhat higher than the loams and silt loams, but lower in phosphorus than the Clyde silty clay loam.

In general it seems from these analyses that phosphorus may be a limiting factor of growth in many of the soils of Fayette county. The content of phosphorus is so low that it is almost certain that there will be an insufficient production of the element in an available form to keep crops supplied. Even where the supply is not so low, there is no assurance of a sufficient production of available phosphorus, and the addition of a soluble phosphorus fertilizer may be desirable. In all cases the amount of phosphorus in the soils of this county is insufficient to last for any period of years and phosphorus will be needed in the near future. Furthermore it seems highly probable that phosphorus fertilizers may be used on many of the soils at the present time with profitable effects, and experimental results carried on in the field and greenhouse would confirm this conclusion. Rock phosphate or acid phosphate may be used and either of these materials may yield desirable effects. Acid phosphate will give more immediate results and is frequently more profitable. Definite conclusions along this line can be drawn, however, only when tests of the relative value of the two materials have been carried out. Farmers may apply these materials to small areas on their own farms and determine for their particular conditions the need of phosphorus, and whether the acid phosphate or the rock phosphate will be the most profitable. The effects of the two phosphorus fertilizers in the experimental results reported later seem to vary considerably under different soil and cropping conditions. It should be emphasized, however, that experimental data secured by the Soils Section, of the Iowa Agricultural Experiment Station, are showing distinctly profitable effects from the application of phosphorus to soils very much like those found in Fayette county.

The nitrogen content of the soils of the county is quite variable ranging from 940 pounds in the Lindley sandy loam up to 9,620 pounds in the Wabash loam of the bottoms. No relation seems to exist between the nitrogen content of the soils in the various groups, altho the bottomland types would average somewhat higher than the upland soils, as might be expected from the fact that the crop production has been low on the bottoms and there has been little removal of the element.

The differences in nitrogen content seem to bear more relation to the soil series or to the particular type, thus the Clyde silty clay loam is the highest of any of the drift soils, while the Carrington types are very much better supplied than the Lindley or Thurston soils on the upland. The Tama silt loam is much higher than the Fayette silt loam on the loessial upland. The Bremer loam on the terraces is much higher than the other types, and the Waukesha is better supplied than the Plainfield, O'Neill or Jackson types. The Wabash soils on the bottoms are much higher than the Cass types. These differences reflect the

characteristics which serve to distinguish the various soil series and soil types. Thus the topographic position of the Clyde and Bremer soils would explain in part their higher nitrogen content. The origin, formation, and previous history would also account for some differences. Thus the Tama silt loam developed under prairie conditions is higher than the Fayette silt loam developed under forest conditions. The Carrington soils are higher than the Lindley for the same reason in part at least and partly also because of the less serious washing to which they have been subjected.

In general the color of the soils within a certain series, one of the basic features which serves to distinguish series, indicates quite definitely the nitrogen content. Soils which are black in color are high in nitrogen and light colored types are the reverse. Textural differences in soils also affect the nitrogen content, thus sandy loams and fine sandy loams are lower in nitrogen than loams. Silt loams are better supplied than loams as a rule and silty clay loams are still higher in this element. A few comparisons of soils of different texture in the same series are possible from these results. Thus the Carrington sandy loam and fine sandy loam are lower than the loam. The Lindley sandy loam and fine sandy loam are lower than the corresponding loam. The O'Neill fine sandy loam is lower than the O'Neill loam and the Cass fine sandy loam is lower than the Cass sandy loam. The Wabash loam, at least the sample analyzed, is much higher in nitrogen than the Wabash silt loam. This is unusual but definite conclusions should not be drawn from this result as Wabash soils are always extremely variable, and then too the sample may have been abnormal. In general it may be said that fine textured soils are better supplied with nitrogen than coarse textured types.

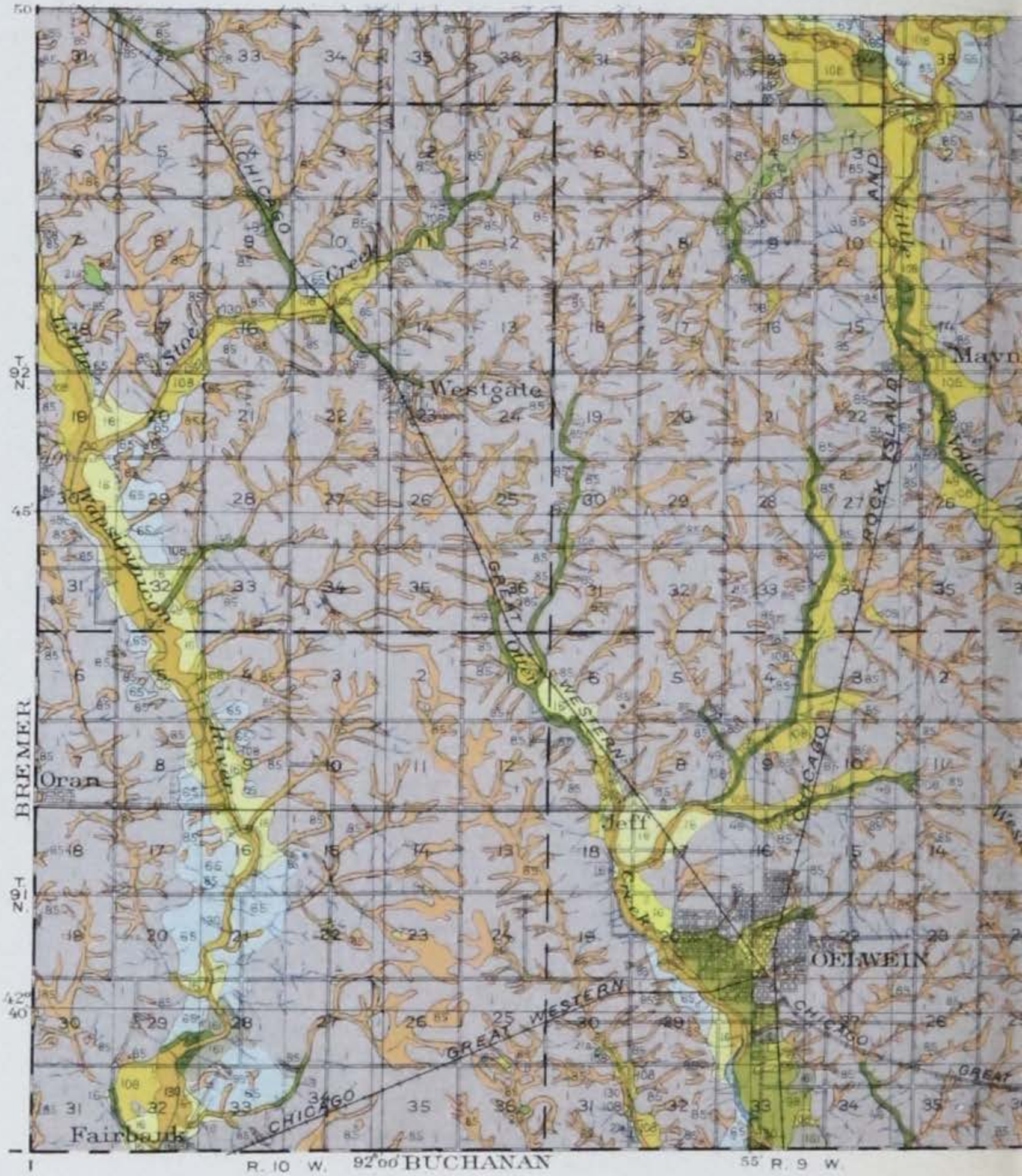
It is evident from these analyses as a whole that with a few exceptions, the soils of the county are very well supplied with nitrogen and in some instances large amounts are present. Nitrogen must not be disregarded, however, in planning systems of permanent fertility for this county. Soils under cultivation lose nitrogen continuously and if the supply is to be kept up, some fertilizing material supplying it must be applied at regular intervals. Farm manure contains much of the nitrogen which has been removed from the soil by growing crops and it serves, therefore, as an important nitrogenous fertilizer. Large increases in crop yields are secured from the use of farm manure and its beneficial effects are undoubtedly due, in part at least, to the nitrogen which it supplies. All the soils of the county should receive applications of farm manure at regular intervals in order to aid in keeping up the nitrogen supply. On the heavy textured soils small amounts may be used with profit, and large applications should not be made preceding the small grain crop of the rotation owing to the danger of lodging. On the light textured types larger applications should be made and in some instances it is necessary to build up the content of nitrogen as well as to keep up the supply.

A second means which may be employed to increase and keep up the nitrogen supply in the soils is the turning under of well inoculated legumes as green manures. Green manuring is necessary on the grain farm as there is no farm manure produced, but on the livestock farm it is also frequently desirable because of the insufficient production of manure to supply all the land. When well in-

# SOIL MAP OF

U. S. DEPT. OF AGRICULTURE, BUREAU OF SOILS  
Milton Whitney, Chief. Curtis F. Marbut in charge Soil Survey

Thomas D. Rice,  
Soils surveyed by A. H. Meyer  
in charge, and H. J. Harper and H. W.



## DRIFT SOILS

- Carrington loam
- Clyde silty clay loam
- Lindley loam
- Lindley sandy loam
- Lindley fine sandy loam
- Carrington sandy loam
- Thurston sandy loam

## LOESS SOILS

- Carrington fine sandy loam
- Fayette silt loam
- Tama silt loam

## TERRACE SOILS

- O'Neill loam
- Plainfield loam

Scale: 1 inch

# WAYETTE COUNTY

## SHEET

Director, Northern Division.  
 U. S. Department of Agriculture,  
 Iowa Agricultural Experiment Station

IOWA AGRICULTURAL EXPERIMENT STATION  
 C. F. Curtis, Director. W. H. Stevenson, in charge Soil Survey  
 P. E. Brown, Associate in charge.



END

- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 20px; height: 10px; background-color: #c8e6c9; border: 1px solid black; margin-right: 5px;"></span> 12 Bremer loam</li> <li><span style="display: inline-block; width: 20px; height: 10px; background-color: #8bc34a; border: 1px solid black; margin-right: 5px;"></span> 126 O'Neill sandy loam</li> <li><span style="display: inline-block; width: 20px; height: 10px; background-color: #c8e6c9; border: 1px solid black; margin-right: 5px;"></span> 98 Plainfield sandy loam</li> <li><span style="display: inline-block; width: 20px; height: 10px; background-color: #9e9e9e; border: 1px solid black; margin-right: 5px;"></span> 81 Jackson silt loam</li> <li><span style="display: inline-block; width: 20px; height: 10px; background-color: #bbdefb; border: 1px solid black; margin-right: 5px;"></span> 75 Waukesha silt loam</li> </ul> | <p>RESIDUAL SOIL</p> <ul style="list-style-type: none"> <li><span style="display: inline-block; width: 20px; height: 10px; background-color: #a1887f; border: 1px solid black; margin-right: 5px;"></span> 164 Sogn clay loam</li> </ul> |
|--|--|
- SWAMP AND BOTTOMLAND SOILS**
- 26 Wabash silt loam

1 mile

oculated, legumes secure a large part of their nitrogen from the air, and hence when they are turned under in the soil they add a considerable amount of this element. If the entire crop is removed, there is of course no addition of nitrogen to the soil, but neither should there be any removal of this element. If the seed only of the legume is taken off and the remainder of the crop turned under, there is a partial green manuring effect and may be a considerable addition of nitrogen. If a part of the crop is plowed under the nitrogen supply may be increased in proportion to the amount of crop utilized in this way. The thoro utilization of crop residues is a third means of maintaining nitrogen in the soil, and these materials should never be wasted as they are very important in permanent fertility. The nitrogen content of the soils of this county may be increased in some instances as necessary and maintained in all cases by the proper use of farm manure, leguminous green manures, and crop residues.

There is usually a distinct relationship apparent between the nitrogen and the organic carbon content in soils. The amount of organic carbon indicates the supply of organic matter, and the color of the soil likewise indicates the content of organic matter. It also shows rather definitely whether or not nitrogen is deficient. Black soils, therefore, are high in organic matter and nitrogen while light colored types are low in both of these constituents. There is considerable variation in the color of the soils in Fayette county, and hence wide differences in organic carbon and nitrogen content might be expected. The range in the amount of organic matter as shown in the table is from 12,175 pounds per acre to 113,677. These amounts are found in the Lindley sandy loam and the Wabash loam respectively, the same types which showed the lowest and highest amounts of nitrogen.

Very much the same relations occur between the various types and the organic carbon content as were noted in the case of nitrogen. Thus the Clyde silty clay loam is the highest of the drift soils. The Carrington types are higher than the Lindley and Thurston soils. The Tama silt loam is higher than the Fayette. The Bremer loam on the terraces is better supplied than the other terrace types and the Wabash soils on the bottoms are higher than the Cass types. Similar relationships between the various types from the textural standpoint are noted as in the case of nitrogen. Thus the fine textured types are higher than the coarse textured. There is also evidence of the effect of topographic position, origin and previous history on the organic matter supply. The relation of the characteristic soil series color to organic carbon has already been noted.

The relation between the carbon and nitrogen indicates the rate at which plant food is made available. If the relation is not at the best, crops may suffer for a lack of necessary plant food. In Fayette county soils, the relation between these two constituents seems to be fairly satisfactory. Only in a few instances is there any evidence that available plant food production is not progressing satisfactorily. In these cases applications of farm manure are of particular value because of the stimulation to available plant food production. In all the soils of the county, however, farm manure should be applied to keep up the supply of organic matter and aid in maintaining the nitrogen content as has been noted. On those types which are black in color and not low in organic matter, smaller amounts may be used, but on most of the types in the county, normal applica-

tions of 8 to 10 tons per acre are very desirable to increase the amount of organic matter as well as to keep up the supply. Crop residues should likewise be used as a means of maintaining the organic matter supply and on the grain farm it is particularly important that green manuring be practiced if soils are not to become deficient in organic matter. By the proper utilization of leguminous green manures and crop residues as substitutes for farm manure or in addition to that material, the organic matter supply in the soils of the county may be kept up under any system of farming.

There is no inorganic carbon present in the surface soils on the uplands in Fayette county except in the case of the residual type, the Sogn clay loam. One of the bottomland soils shows a small amount of inorganic carbon. Both of these types are minor in area and in agricultural importance and hence it may be said that the soils of the county are generally lacking in lime and acid in reaction. The need of testing the soils for lime requirement is therefore evident. They should all be tested and the proper amount of lime applied if satisfactory crop growth, particularly of legumes is to be secured.

The requirements shown in the table should be taken as indicative only of the needs of the soils and applications of lime should be made only after the test has been run on a sample from that particular field. Soils vary widely in lime requirement and even within the same type wide differences may occur. The

TABLE V. PLANT FOOD IN FAYETTE COUNTY, IOWA, SOILS. POUNDS PER ACRE OF FOUR MILLION POUNDS OF SUB-SURFACE SOIL (6 2/3"-20")

Soil No.	Soil Type	Total Phosphorus	Total Nitrogen	Total Organic Carbon	Total Inorganic Carbon	Lime'n requirement
DRIFT SOILS						
1	Carrington loam	1,589	5,346	38,858	0	7,000
85	Clyde silty clay loam	1,764	5,680	70,573	0	1,000
65	Lindley loam	1,400	640	9,282	0	6,000
161	Lindley sandy loam	1,346	880	13,431	0	3,000
136	Lindley fine sandy loam	836	880	7,644	0	2,000
3	Carrington sandy loam	1,752	3,920	46,956	0	5,000
162	Thurston sandy loam	1,953	1,040	20,947	0	2,000
4	Carrington fine sandy loam	1,616	3,680	40,404	0	3,000
LOESS SOILS						
163	Fayette silt loam	1,266	1,684	20,311	0	4,000
120	Tama silt loam	3,072	16,400	177,196	0	1,000
TERRACE SOILS						
108	O'Neill loam	2,007	3,360	49,468	0	5,500
16	Plainfield loam	1,454	800	4,914	0	3,000
12	Bremer loam	1,670	3,480	49,249	0	8,000
126	O'Neill sandy loam	1,778	2,000	35,162	0	5,000
98	Plainfield sandy loam	1,212	640	18,018	0	2,000
81	Jackson silt loam	2,398	2,240	25,880	0	2,000
75	Waukesha silt loam	2,262	7,280	98,498	0	6,000
SWAMP AND BOTTOMLAND SOILS						
26	Wabash silt loam	3,847	9,080	108,372	0	1,000
49	Wabash loam	4,042	15,840	198,744	0	6,000
130	Cass fine sandy loam	1,778	3,800	59,841	0	6,000
19	Cass sandy loam	1,832	2,240	31,995	0	6,000
RESIDUAL SOIL						
164	Sogn clay loam	2,208	4,970	56,797	31,000	0



TABLE VI. PLANT FOOD IN FAYETTE COUNTY, IOWA, SOILS. POUNDS PER ACRE OF SIX MILLION POUNDS OF SUBSOIL (20"-40")

Soil No.	Soil Type	Total Phosphorus	Total Nitrogen	Total Organic Carbon	Total Inorganic Carbon	Lime's requirement
DRIFT SOILS						
1	Carrington loam	1,346	3,400	42,097	0	6,333
85	Clyde silty clay loam	2,061	2,580	31,712	720	0
65	Lindley loam	1,860	840	12,776	0	9,000
161	Lindley sandy loam	1,092	1,140	10,648	0	3,000
136	Lindley fine sandy loam	1,011	740	6,224	0	2,000
3	Carrington sandy loam	2,547	4,500	52,743	0	5,000
162	Thurston sandy loam	2,628	990	22,511	0	1,000
4	Carrington fine sandy loam	1,455	1,980	17,478	540	0
LOESS SOILS						
163	Fayette silt loam	2,384	2,160	18,427	0	5,000
120	Tama silt loam	2,304	2,340	27,846	0	5,000
TERRACE SOILS						
108	O'Neill loam	2,163	630	20,885	0	3,000
16	Plainfield loam	2,304	300	20,146	0	3,000
12	Bremer loam	2,262	1,500	33,087	0	8,000
126	O'Neill sandy loam	1,941	1,320	31,285	0	2,000
98	Plainfield sandy loam	2,100	....	12,783	1,140	0
81	Jackson silt loam	4,404	1,500	20,966	0	5,000
75	Waukesha silt loam	2,748	5,220	63,063	0	6,000
SWAMP AND BOTTOMLAND SOILS						
26	Wabash silt loam	3,918	8,760	77,343	0	2,000
49	Wabash loam	2,787	12,600	180,180	0	6,000
130	Cass fine sandy loam	1,941	840	25,442	20,800	0
19	Cass sandy loam	4,242	6,900	86,158	0	6,000
RESIDUAL SOIL						
164	Sogn clay loam	3,938	210	24,937	383,580	0

analyses reported here serve merely to indicate the general need of lime on the soils of the county and farmers are urged to have their soils tested and to apply the lime shown to be necessary according to the tests, if they expect to secure the most satisfactory crop growth. One test will not be sufficient for all time and every soil should be tested at least once in the rotation, preferably preceding the legume if the supply of lime is to be maintained.

#### THE SUBSURFACE SOILS AND SUBSOILS

The results of the analyses of the subsurface soils and subsoils, are given in tables V and VI. They are calculated on the basis of 4,000,000 pounds of subsurface soils and 6,000,000 pounds of subsoil per acre.

Apparently the lower soil layers in Fayette county are not high in any of the essential plant food constituents, showing very much the same content as the surface soils in most instances and smaller amounts in other cases. There can be little effect, therefore, on the fertility of the soil and the analyses of the surface soils may be considered to indicate quite definitely their needs. It seems unnecessary to consider the analyses of the lower soil layers in detail. They serve merely to emphasize the needs of the soils of the county as indicated in the analyses of the surface soil. Phosphorus fertilizers will certainly be needed in the future and might be of value in many cases at the present time. The supply of

organic matter and nitrogen must be maintained thru a proper utilization of farm manure, crop residues and leguminous green manures. On some of the types it is necessary that the amounts of the above mentioned materials should be increased. They must be used, however, for permanent fertility even where the soils are apparently fairly well supplied. Only in the case of the Sogn clay loam and Cass fine sandy loam, the two types which were basic in the surface soil, is there any large content of lime in the lower soil layers. In three other instances the subsoils are basic and there are small amounts of inorganic carbon present. In these instances the amount is so small, that it would have little effect on the needs of the surface soil. Lime rarely moves upward in the soil and small amounts in the subsoil are practically insignificant. The conclusion seems warranted, therefore, that on all the upland types in the county, except the Sogn clay loam and on all the bottomland soils except the Cass fine sandy loam, lime is necessary if crop growth is to be satisfactory. Certainly these soils should all be tested before legumes are grown and tests should be made at regular intervals at least once in the rotation, in order that the supply of lime may be kept up.

#### GREENHOUSE EXPERIMENTS

Two greenhouse experiments were carried out on the soils from Fayette county in the attempt to secure some information regarding the fertilizer needs of the soils and the value of the application of certain fertilizer materials. The Carrington loam and the Fayette silt loam, the two most important types in the county were used. In addition greenhouse experiments on the Tama silt loam and the O'Neill sandy loam in Black Hawk county are included inasmuch as these types occur in Fayette county.

The treatments employed in all the experiments include the application of manure, lime, rock phosphate, acid phosphate and a complete commercial fertilizer. The amounts of these materials applied were the same as those used in the field tests, and the results of these greenhouse experiments may therefore be considered to indicate rather definitely the fertilizer effects which may be secured in the field. Manure was applied at the rate of 8 tons per acre, lime was added in sufficient amounts to neutralize the acidity of the soil and supply two tons additional. Rock phosphate was added at the rate of 2,000 pounds per acre, acid phosphate at the rate of 200 pounds per acre and a standard 2-8-2 brand of a complete commercial fertilizer at the rate of 300 pounds per acre. Wheat and clover were grown in the experiments, clover being seeded about one month after the wheat was up. In the experiments on the soils of Fayette county, only the clover yields are given as the wheat yields were not secured.

The results of the experiment on the Carrington loam are given in table VII,

TABLE VII. GREENHOUSE EXPERIMENT, CARRINGTON LOAM—FAYETTE COUNTY

Pot No.	Treatment	Weight green clover in grams
1	Check	4.53
2	Manure	15.87
3	Manure+Lime	18.14
4	Manure+Lime+Rock phosphate	29.48
5	Manure+Lime+Acid phosphate	24.94
6	Manure+Lime+Complete commercial fertilizer	29.48



Fig. 2. Clover pot culture on Tama silt loam.

the figures being the averages of the yields on the duplicate pots. Manure brought about a very distinct increase in the clover, and the addition of lime gave a still further increase. The rock phosphate, acid phosphate and complete commercial fertilizer all gave very definite increases on the clover, the acid phosphate proving slightly less effective than the other two materials. It would seem from these results that the Carrington loam in Fayette county would respond profitably to applications of farm manure, lime, and a phosphate fertilizer. The results are not definite enough to show whether rock phosphate or acid phosphate should be used and farmers should test the two materials on their own soils in order to determine which material should be employed. There is no evidence that the complete commercial fertilizer would prove as desirable as a phosphorus carrier, for while similar increases were secured, the cost of the material is greater and the increased yields secured would be less profitable.

The second greenhouse experiment was on the Fayette silt loam from Fayette county and the results are given in table VIII. Again there was a large effect from the application of manure on the clover crop. Lime in addition to manure gave over twice as large a crop as that secured with manure alone. Rock phosphate had little effect in addition to the lime and manure, but acid phosphate and the complete commercial fertilizer both proved beneficial, the acid phosphate showing up very much better than the complete fertilizer. The value of the acid phosphate on this soil is shown very definitely in these results, and it seems to be very much superior to rock phosphate. Further tests are of course necessary before definite conclusions can be drawn. These results on the Fayette silt loam

TABLE VIII. GREENHOUSE EXPERIMENT—FAYETTE SILT LOAM,  
FAYETTE COUNTY

Pot No.	Treatments	Weight green clover in grams
1	Check	24.94
2	Manure	31.75
3	Manure+Lime	81.64
4	Manure+Lime+Rock phosphate	88.45
5	Manure+Lime+Acid phosphate	142.88
6	Manure+Lime+Complete commercial fertilizer	111.13



Fig. 3. Wheat and clover on Tama silt loam.

indicate, however, that manure, lime and phosphorus are necessary treatments for the best crop production on this type. Farmers are urged to test the value of phosphorus and to determine for their own conditions which phosphate fertilizer can be used most profitably.

The results obtained in the greenhouse experiment on the Tama silt loam from Black Hawk county are given in table IX. Manure had little effect on the wheat but there was an enormous increase in clover. Lime also gave little effect on the wheat but brought about a very large increase in the clover. This effect might be expected since clover and other legumes are much more sensitive to acidity than the grain crops. Rock phosphate applied with manure and lime increased the wheat yields and also gave some effect on the clover. Acid phosphate had no effect on the wheat but brought about a considerable increase on the clover. The complete commercial fertilizer increased the wheat yields but to a smaller extent than did the rock phosphate. It also increased the yield of clover but had less effect on that crop than the acid phosphate. It seems evident that on this soil type, manure and lime bring about considerable effects partic-

TABLE IX. GREENHOUSE EXPERIMENT, TAMA SILT LOAM—BLACK HAWK COUNTY

Pot No.	Treatments	Weight wheat grain in grams	Weight clover in grams
1	Check	12.00	8.0
2	Manure	12.65	31.0
3	Manure+Lime	12.86	51.5
4	Manure+Lime+Rock phosphate	14.03	57.0
5	Manure+Lime+Acid phosphate	12.72	64.5
6	Manure+Lime+Complete commercial fertilizer	13.67	59.5

ularly on clover, and phosphate fertilizers will probably give profitable returns. No conclusions regarding the relative merits of the two phosphates should be drawn. Apparently the complete commercial fertilizer is less desirable than a phosphate fertilizer.

The results from the greenhouse experiment on the O'Neill sandy loam in Black Hawk county are given in table X. Only the wheat yields are shown. The application of manure brought about a slight increase in the wheat crop, and lime with manure showed a small gain. Rock phosphate applied with lime and manure gave a very distinct increase in the wheat yields. Acid phosphate, however, had no effects. The complete commercial fertilizer brought about a somewhat larger effect than the rock phosphate. It is evident that on this soil applications of manure, lime, and phosphorus would bring about profitable effects. The results do not show definitely which phosphorus fertilizer should be employed as the differences are not large enough and tests of the two materials should be made in the field. Complete commercial fertilizers are probably less desirable, however, than the phosphorus carriers.

### FIELD EXPERIMENTS

The field experiments which have been started in Fayette county have not yet been under way for a long enough period for the securing of definite results. Such experiments must be carried on for several years before conclusions can be drawn from them. The data obtained in these experiments will be published later in a supplementary report. There are some experiments under way, however, in adjacent counties which have been running for several years and the results obtained on some of these fields are included in this report to indicate the effects of certain fertilizer treatments on some of the important soil types in this

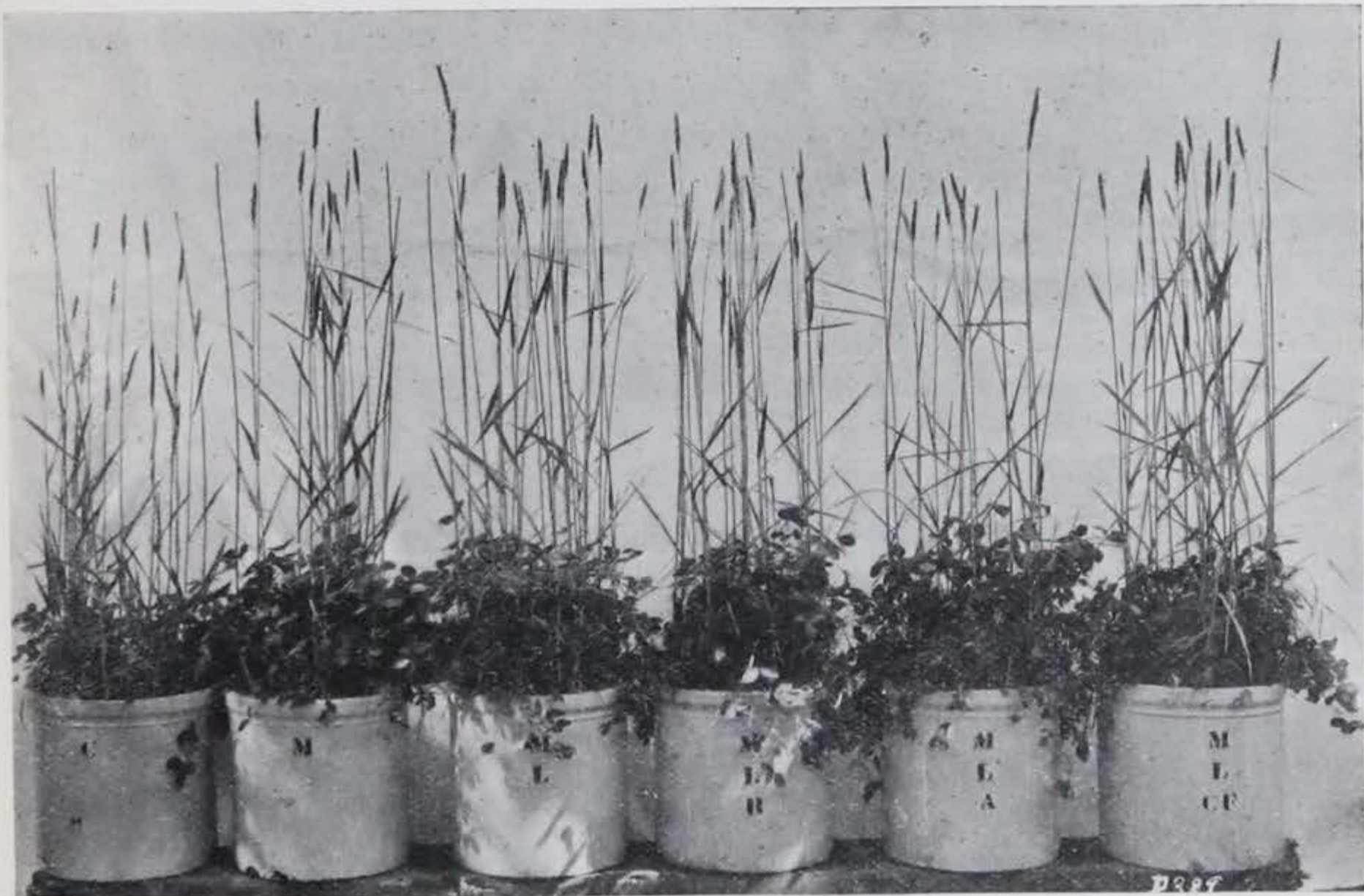


Fig. 4. Wheat on O'Neill sandy loam.

TABLE X. GREENHOUSE EXPERIMENT, O'NEILL SANDY LOAM  
BLACK HAWK COUNTY

Pot No.	Treatment	Weight wheat grain in grams
1	Check	8.01
2	Manure	8.38
3	Manure+Lime	8.70
4	Manure+Lime+Rock phosphate	10.94
5	Manure+Lime+Acid phosphate	8.48
6	Manure+Lime+Complete commercial fertilizer	11.41

county. These experiments are located on soil types which are the same as those occurring extensively in Fayette county and the results may be considered applicable, therefore, to this county.

These field experiments are all planned with the idea of determining the relative value of various soil treatments and they are laid out on land which is entirely representative of the individual soil type. They are permanently located by the installation of corner stakes and all precautions are taken in the application of fertilizers and in the harvesting of the crops, to be sure that accurate results are secured. In all these fields, tests are included under both the livestock and the grain systems of farming, manure being applied in the former and crop residues being utilized in the latter. Only the results on the livestock system plots are included here as there has not been opportunity as yet for the crop residue treatments to show up any definite effects. Other fertilizing materials tested include limestone, rock phosphate, acid phosphate and a complete commercial fertilizer. Manure is applied at the rate of 8 tons per acre once in a four year rotation. Limestone is used in sufficient amounts to neutralize the acidity of the soil and supply two tons additional. Rock phosphate is added at the rate of 2,000 pounds per acre once in the rotation, acid phosphate at the rate of 200 pounds per acre annually. Up until the last year the old standard 2-8-2 complete commercial fertilizer was used at the rate of 300 pounds per acre annually. The new standard 2-12-2 complete commercial fertilizer is now being employed, and is applied at the rate of 267 pounds per acre annually, thus supplying an equivalent amount of phosphorus to that contained in the 200 pounds of 16 percent acid phosphate. The plots in these experiments are 155' 7" by 28', making them one-tenth of an acre in size.

## THE WAVERLY FIELD NO. I

The results on the Waverly Field No. I, Series I, are given in table XI. The field is located in Bremer county on the Carrington loam which is the most ex-

TABLE XI. FIELD EXPERIMENT—WAVERLY FIELD NO. I, SERIES I.  
CARRINGTON LOAM—BREMER COUNTY

Plot No.	Treatment	Oats	Clover	Corn	Oats	Corn
		Bu. per acre 1918	T's per acre 1919	Bu. per acre 1920	Bu. per acre 1921	Bu. per acre 1922
1	Check	46.6	1.40	85.3	36.8	54.9
2	Manure	57.2	1.84	89.0	38.9	57.6
3	Manure+Lime	49.1	2.02	87.8	35.4	60.5
4	Manure+Lime+Rock phosphate	67.0	2.10	94.0	46.5	64.1
5	Manure+Lime+Acid phosphate	62.5	3.10	101.5	45.2	74.9
6	Manure+Lime+Complete commercial fertilizer	58.5	2.84	94.2	40.7	81.0

tensive soil type in Fayette county. The results secured are therefore applicable to the Carrington loam in Fayette county and the fertilizer treatments indicated as desirable would undoubtedly produce similar effects on the same type in the latter county. The application of manure brought about a distinct effect on all the crops in the rotation, the influence being particularly noticeable in the case of the clover. Lime in addition to manure increased the clover yield considerably but had no effect in the corn and oats except in 1922 when there was a distinct increase in the corn yields. The application of rock phosphate showed large effects on all the crops and acid phosphate proved still more beneficial in most cases. It had a very much larger effect on the clover in 1919 and the corn in 1920 and 1922 than did the rock phosphate. Less effect was evidenced from the acid phosphate, however, on the two oats crops. The complete commercial fertilizer showed less effect than the phosphates on the oats but was somewhat more effective than the rock phosphate on the clover and the corn in 1920, having less effect than the acid phosphate, however, on these particular crops. In 1922 the complete fertilizer gave larger effects than either the acid phosphate or the rock.

It would seem, from these results, that the Carrington loam may be benefitted very largely by the addition of manure, lime, and phosphorus. Lime gives distinctly beneficial effects on the clover crop of the rotation. Rock phosphate and acid phosphate both show large increases, the acid phosphate proving more desirable on the corn and clover but showing slightly smaller effects on the oats. The complete commercial fertilizer did not give results which would warrant its use. In only one instance did it produce greater effects than the acid phosphate and in that case the difference was not sufficient to pay for the greater cost of the material. In general it seems that the phosphates would probably prove more profitable on this soil.

#### THE WAVERLY FIELD NO. II SERIES I

The results obtained on the Waverly Field No. II, Series I, are given in table XII. Manure brought about a distinct effect on the corn, oats, and clover, showing the largest effect on the oats. Lime in addition to manure increased the yields of all the crops except the clover in 1919. This is evidently an abnormal result as lime ordinarily gives very beneficial effects on clover. Field experience and the results of other tests on this same soil, indicate desirable results from the use of lime. The plot gives evidence of abnormality again in 1921 when a

TABLE XII. FIELD EXPERIMENT—WAVERLY FIELD NO. II, SERIES I.  
CARRINGTON LOAM—BREMER COUNTY

Plot No.	Treatment	Oats Bu. per acre 1918	Clover Tons per acre 1919	Corn Bu. per acre 1920	Oats Bu. per acre 1921	Clover Tons per acre 1922
1	Check	42.8	1.5	47.8	25.7	2.2
2	Manure	61.0	1.8	56.5	34.3	2.2
3	Manure+Lime	64.9	1.1*	57.5	50.6*	2.3
4	Manure+Lime+Rock phosphate	65.5	2.6	58.0	40.3	2.1
5	Manure+Lime+Acid phosphate	67.2	2.9	47.0	42.0	2.9
6	Manure+Lime+Complete commercial fertilizer	72.1	2.4	....	35.7	2.8

\*Results evidently abnormal.

TABLE XIII. FIELD EXPERIMENT—WAVERLY FIELD NO. II, SERIES II.  
CARRINGTON LOAM—BREMER COUNTY

Plot No.	Treatment	Corn Bu. per acre 1918	Oats Bu. per acre 1919	Clover Tons per acre 1920	Clover and Timothy Tons per acre 1921	Corn Bu. per acre 1922
1	Check	38.5	39.8	0.47	1.0	39.4
2	Manure	54.0	49.3	0.67	1.3	55.7
3	Manure+Lime	56.8	.....	1.36	1.8	62.3
4	Manure+Lime+Rock phosphate	57.2	46.4	1.66	1.9	63.1
5	Manure+Lime+Acid phosphate	60.5	57.8	2.05	2.1	64.0
6	Manure+Lime+Complete commercial fertilizer	61.3	61.9	1.99	2.5	62.9

very large yield of oats was secured. Rock phosphate brought about an increase in all of the crops, except the clover in 1922. Acid phosphate gave a further increase in the case of the oats and clover but had no effect on the corn in 1920. The complete commercial fertilizer showed more effect than the phosphates on the oats in 1918 but had a smaller effect on the same crop in 1921. It gave less effect than the acid phosphate in the case of both clover crops. The crop yield of corn for this plot in 1920 is not included because of very evident abnormality. In general these results confirm those secured on the Waverly Field No. I. showing the beneficial effects of manure, lime and phosphorus on the Carrington loam. No definite evidence is given regarding the relative merits of the two phosphates, but in general it seems that either of them will prove more profitable than the complete commercial fertilizer.

#### THE WAVERLY FIELD NO. II SERIES II

The results obtained on the Waverly Field No. II, Series II, on the Carrington loam in Bremer county, are given in table XIII. Manure gave a very definite increase in the yields of all the crops showing the most pronounced effect on the corn. Lime in addition to manure increased the yields of corn, clover, and clover and timothy. The results are not given in the case of the oats because of very evident abnormality. Apparently lime brings about a particularly large effect on the clover on this soil. Rock phosphate had little effect on the corn and oats but gave increases in the clover and in the clover and timothy. Acid phosphate showed large effects, however, on all four crops, the beneficial influence being shown particularly on the oats and clover. The complete commercial fertilizer gave slightly larger increases than the acid phosphate on all crops except the clover and the corn in 1922. With the clover, however, it showed more effect than the rock phosphate. Evidently manure, lime, and phosphorus, may be used profitably on the Carrington loam. These results would indicate some superiority for acid phosphate over rock phosphate, but the differences are not very large and tests on individual farms are very desirable. The complete commercial fertilizer does not seem to be as desirable on this type as the acid phosphate.

#### THE JESUP FIELD

The results obtained on the Jesup Field, on the Carrington loam in Black Hawk county, are given in table XIV. Manure gave a large increase in all



TABLE XIV. FIELD EXPERIMENT—JESUP FIELD—CARRINGTON LOAM  
BLACK HAWK COUNTY

Plot No.	Treatment	Oats Bu. per acre 1918	Clover Tons per acre 1919	Clover and Timothy Tons per acre 1920	Corn Bu. per acre 1921	Corn Bu. per acre 1922
1	Check	71.9	1.17	0.50	58.7	51.4
2	Manure	71.6	2.08	0.85	72.8	65.6
3	Manure+Lime	83.1	1.92	1.20	77.6	71.1
4	Manure+Lime+Rock phosphate	81.8	1.86	1.15	78.1	73.4
5	Manure+Lime+Acid phosphate	76.1	2.22	1.12	75.5	73.4
6	Manure+Lime+Complete commercial fertilizer	77.2	2.80	1.25	78.7	77.6

the crops except the oats in 1918. Lime increased the yield of clover and timothy in 1920 but had no effect on the clover in 1919. Ordinarily this material should show a beneficial effect on clover. The oats and corn crops were increased in all cases by the use of lime. Rock phosphate showed small effects on the corn, but gave no indications of value on the other crops. Acid phosphate increased the yields of clover and corn, but had little effect on the oats or the clover and timothy. The complete commercial fertilizer gave a large increase in clover and in the clover and timothy, and showed slightly larger effects than the phosphates with both corn crops. It had a somewhat smaller effect, however, in the case of the oats.

These results serve to confirm the previous observation that the Carrington loam will respond to applications of manure, lime and phosphorus. Whether rock phosphate or acid phosphate should be employed is not definitely shown, altho there is some evidence of greater value from the acid phosphate. In no case does the complete commercial fertilizer show effects which would warrant its use.

## THE ELDORA FIELD

The results obtained on the Eldora Field, Series II, on the Carrington loam in Hardin county are given in table XV. Manure brought about large increases in the yields of all the crops, showing particularly large effects on the oats in 1921. Lime gave increases in the case of the clover and corn and on the oat crop in

TABLE XV. FIELD EXPERIMENT—ELDORA FIELD, SERIES II.  
CARRINGTON LOAM—HARDIN COUNTY

Plot No.	Treatment	Oats Bu. per acre 1917	Clover Tons per acre 1918	Corn Bu. per acre 1919	Corn Bu. per acre 1920	Oats Bu. per acre 1921	Clover Tons per acre 1922
1	Check	60.1	0.71	46.4	60.9	26.6	1.2
2	Manure	66.4	1.13	50.0	62.5	38.0	1.4
3	Manure+Lime	65.7	1.27	51.8	65.6	41.8	1.3
4	Manure+Lime+Rock phosphate	72.6	2.87	53.6	71.8	50.3	2.1
5	Manure+Lime+Acid phosphate	85.5	2.56	57.2	68.7	48.7	2.6
6	Manure+Lime+Complete commercial fertilizer	80.0	1.88	51.7	.....	54.6	2.6

TABLE XVI. FIELD EXPERIMENT—HUDSON FIELD—TAMA SILT LOAM  
BLACK HAWK COUNTY

Plot No.	Treatment	Corn	Oats	Corn	Corn	Oats
		Bu. per acre 1918	Bu. per acre 1919	Bu. per acre 1920	Bu. per acre 1921	Bu. per acre 1922
1	Check	45.8	47.6	53.2		44.8
2	Manure	49.3	54.7	62.8	no	53.1
3	Manure+Lime	54.4	59.2	67.4	crop	59.6
4	Manure+Lime+Rock phosphate	56.5	64.9	73.3	se-	58.1
5	Manure+Lime+Acid phosphate	57.4	62.2	73.3	cured	53.2
6	Manure+Lime+Complete commercial fertilizer	58.5	57.5	72.4		62.2

1921. No effect was evidenced, however, on the oats in 1917. Neither was the clover yield in 1922 increased. Ordinarily, however, lime shows pronounced effects on the clover grown on this soil. Rock phosphate gave increases for all the crops showing the most pronounced effect on the clover and on the oats in 1921. Acid phosphate gave much larger effects on the oats in 1917 but a smaller effect on the same crop in 1921. It showed less effect on the clover in 1918. It had a greater influence on the clover in 1922. The complete commercial fertilizer showed less effect than the acid phosphate in all cases except on the oats in 1921. It gave a greater effect, however, than the rock phosphate on the oats in 1917 and 1921 and on the clover in 1922.

These results offer further confirmation of the value of manure, lime and phosphorus on the Carrington loam. They emphasize the need for testing acid phosphate and rock phosphate on the farm to determine which material can be most profitably employed. The complete commercial fertilizer did not yield results which were sufficiently greater than those brought about by the phosphates to warrant its use.

#### THE HUDSON FIELD

The results obtained on the Hudson Field on the Tama silt loam in Black Hawk county are given in table XVI. Manure gave distinct increases in the various crops grown on this field showing the largest effects on the corn in 1920. Lime in addition to manure gave further increases in all cases. Rock phosphate proved of value with all the crops and the same was true for acid phosphate, the two materials yielding very much the same effects except that the acid phosphate was less effective on the oats in 1922. The complete commercial fertilizer proved superior to the phosphates on the corn in 1918 and on the oats in 1922, but the reverse was true in the case of the oats in 1919 and the corn in 1920. It seems apparent from these results that the Tama silt loam responds to applications of manure, lime and phosphorus. Whether rock phosphate or acid phosphate should be employed must be determined for the particular farm conditions. Complete commercial fertilizers are apparently less desirable than the use of phosphates.

#### AVERAGE RESULTS ON THE CARRINGTON LOAM

Average results obtained from all the field experiments in the state on the Carrington loam are given in table XVII. The check or untreated plot averages are calculated from the yields on the three check plots in each field, 1, 7, and 13, and averages are struck from the check yields on all the fields. There is

rather definite evidence supplied in this table to show the value of applications of various fertilizers to this soil, and as a large number of fields are represented and many crop yields are included, the results may be considered quite conclusive.

The application of manure showed a distinctly beneficial effect on the corn, oats and clover. Lime with manure gave very distinct increases in all cases, the results being quite as definite on the corn and oats as on the clover. Rock phosphate with manure and lime proved of value on all the crops and acid phosphate showed very similar increases on the corn and oats but proved distinctly superior on the clover. The complete commercial fertilizer gave increases in the corn and oats yields which were very similar to those brought about by the phosphates, and in the case of the clover showed an effect very similar to that of the acid phosphate. The crop residues showed little effect on any of the crops. Lime again gave definite increases in all cases. The rock phosphate and acid phosphate both increased the yields of all the crops, the acid phosphate proving superior to the rock in all cases. The complete commercial fertilizer showed larger effects on all the crops than did the phosphates, but the differences were not large enough to warrant the use of the higher priced material.

These average figures confirm those obtained on the individual fields reported earlier, and bear out the conclusions that the Carrington loam will respond profitably to applications of manure, lime and phosphorus. Acid phosphate seems to be superior to the rock under the grain system of farming and also shows larger effects on the clover in the livestock system. Tests on the individual farm are necessary, however, if that material is to be used which will give the most desirable effects under any particular conditions. Complete commercial fertilizers

TABLE XVII. CARRINGTON LOAM—AVERAGE CROP YIELDS AND INCREASE DUE TO FERTILIZER TREATMENT—IOWA EXPERIMENT FIELDS

Treatment	Corn*		Oats*		Clover*	
	Av. Yield Bu. per acre	Increase for treatment Bu. per acre	Av. Yield Bu. per acre	Increase for treatment Bu. per acre	Av. Yield Tons per acre	Increase for treatment Tons per acre
Check	51.9		43.6		1.25	
Manure	58.8	6.9	49.6	6.0	1.38	0.13
Manure+Lime	62.6	10.7	53.0	9.4	1.57	0.32
Manure+Lime+Rock phosphate	66.0	14.1	62.3	18.7	1.97	0.72
Manure+Lime+Acid phosphate	66.3	14.4	60.8	17.2	2.27	1.02
Manure+Lime+Complete commercial fertilizer	66.8	14.9	62.4	18.8	2.29	1.04
Crop Residues	54.7	2.8	47.3	3.7	1.37	0.12
Crop Residues+Lime	57.5	5.6	49.3	5.7	1.41	0.16
Crop Residues+Lime+Rock phosphate	61.8	9.9	51.2	7.6	1.80	0.55
Crop Residues+Lime+Acid phosphate	62.4	10.5	52.7	9.1	1.94	0.69
Crop Residues+Lime+Complete commercial fertilizer	64.2	12.3	58.2	14.6	2.02	0.77

\*Corn Yields averaged from 20 crops on 10 fields, oats from 9 crops on 5 fields and clover from 15 crops on 9 fields.

are apparently less desirable than the phosphates inasmuch as they are more expensive and do not bring about crop increases which are consistently greater than those obtained by the use of the phosphorus carriers.

### THE NEEDS OF FAYETTE COUNTY SOILS AS INDICATED BY LABORATORY, GREENHOUSE AND FIELD TESTS

The treatments recommended for the soils of Fayette county are based upon the laboratory, greenhouse and field experiments described earlier in this report. They are also based upon practical experience on the farm and no suggestions are made which have not been proven to be of value by much farm experience.

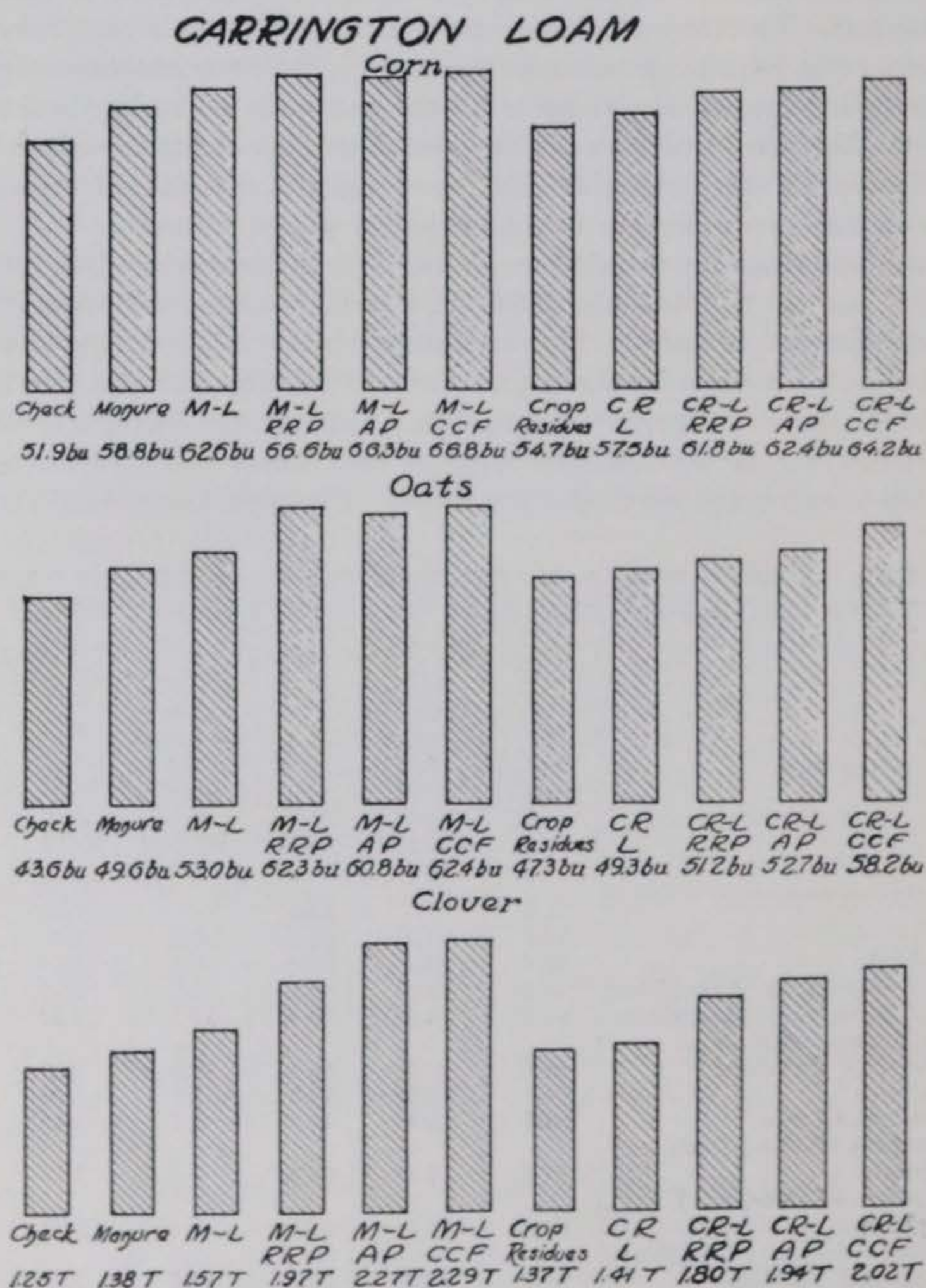


Fig. 5. These columns show the different yields of crops secured by different soil treatments on Carrington silt loam area.

The field experiments which have been discussed while located in other counties are laid out on soil types which occur extensively in Fayette county, and hence the results may be considered to show quite accurately the effects which may be secured by the use of the same fertilizing materials on the soils of this county. Results will be available later from field tests in this county, but the data given here certainly give definite evidence of the principal needs of the soils of Fayette county. It should be noted that no suggestions are made except those which may readily be carried out on the farm. The tests recommended are simple and may be carried out without difficulty on any farm. Similar fertilizer tests are now under way on many farms and farmers are securing data of much practical value to themselves as well as to others farming on the same soils. The Soils Section of the Iowa Agricultural Experiment Station will aid farmers who wish to carry out tests on their own soils and complete instructions are given in Circular No. 82. It should be emphasized that the relative value of the two phosphorus fertilizers may be determined quite readily on the farm and only in this way can definite conclusions be reached as to the desirability of the use of the one or the other material.

### LIMING

The soils of Fayette county are practically all acid in reaction and hence in need of lime. Only two minor types show a basic reaction in the surface soil and these are the only types which contain any considerable amount of lime in the lower soil layers. The upland soils are all in need of considerable amounts of lime if the growth of crops particularly of legumes is to be satisfactory. Red clover and alfalfa are especially sensitive to acid conditions while the grain crops are less affected. When cultivated, soils lose lime quite rapidly thru leaching and in other ways and even in the few instances in which the subsoils contain small amounts of lime, acidity will occur in the near future. But the content of lime in the lower soil layers has little effect on the needs of the surface soil and when they are acid, lime should be applied. There is little movement of lime upward in the soil but a continuous washing away of the material in the drainage water.

Lime is of value on soils because it improves their physical, chemical and bacteriological conditions. It tightens up light, sandy soils, making them less drouthy and more retentive of plant food constituents and it opens up tight, clay soils, making them better aerated and more suitable for the production of available plant food. Chemically, lime effects the soil by neutralizing the acids which are present or are produced in the decomposition of organic matter. The element calcium is supplied and this may be of distinct value in the case of certain crops. Bacterial conditions in soils are improved by liming as most of the desirable bacteria are less active in the absence of lime. The decomposition of organic matter is stimulated, nitrate production is greater, nitrogen fixation is increased, and in general the production of available plant food by bacteria, is very much larger where lime is applied to acid soils. In individual cases, increases in crop yields brought about by liming may be due to the physical, the chemical, or the bacteriological effects, but in general the results are due to an improvement of the soils from all three standpoints.

The data given earlier in this report indicate roughly the needs of the individual soil types in the county but they should not be interpreted to show how much lime should be applied in any one case. The lime requirement of soils is extremely variable and the amount of lime which should be used should be determined in every case by testing a sample of the particular soil. Variations in need of lime occur even within the same type and are often quite striking in different fields on the same farm. If the proper amount of lime is to be used, the particular soil must be tested. Farmers may test their own soils and determine how much lime to employ but in general it will undoubtedly be more satisfactory for them to send a small sample to the Soils Section of the Iowa Agricultural Experiment Station and have it tested free of charge.

It is very essential for successful crop production in Fayette county, that farmers test their soils and apply lime as it is needed. Often legumes will fail on acid soils and the most successful yields of any farm crop cannot be secured under acid conditions. One application of lime will not be sufficient to keep the soils supplied indefinitely and hence soils should be tested at regular intervals if the lime supply is to be maintained. It is suggested that tests be made once in a four year rotation preceding the legume crop of the rotation and lime may then be applied with the largest possible effect.

Liming is a fundamental practice for the maintenance of permanent fertility as well as for the securing of the best crops at the present time, and all systems of soil management must include the use of lime when needed. The results given earlier in this report, show that yields of general farm crops in Fayette county may be increased by liming and farm experience confirms this conclusion. Hence, for permanent fertility and for the most profitable crop results now, farmers of Fayette county must plan on using lime whenever necessary. Further information regarding the loss of lime from soils, the demand for lime by certain crops, and other points in connection with liming, are given in Bulletin 151 and Extension Circular 105 of the Iowa Agricultural Experiment Station.

### MANURING

The supply of organic matter in many of the soils of Fayette county is not large and in many cases it is too low for the best crop production. Only in two of the soil types is there any large occurrence of organic matter. These are the Clyde silty clay loam and the Wabash loam. The latter is a bottomland type and very black in color. The former occurs on the uplands but in depressed poorly drained areas and it, too, is black in color. The soils of the Carrington series on the upland are somewhat lighter in color, being usually a dark brown. This lighter color corresponds to a lower content of organic matter and similarly on the soils of the terraces which are brown in color the content of organic matter is not high. On the still lighter colored types such as the Lindley, the O'Neill, the Plainfield and the Jackson soils, the content of organic matter is rather low. It would be expected, therefore, that manure would prove of large value on many of the soils of this county and particularly on the light colored types. Beneficial effects are noted, however, on practically all of the soils. The types in the Carrington series which are brown in color, and all the other similarly color-

ed soils, give large returns from the application of manure. Even on those types which are black in color, small amounts of manure prove of value. Farm manure is unquestionably the most valuable fertilizing material which can be used in this county, and if the largest crop yields are to be secured and soils are to be kept permanently productive the farmers should see to it that all the manure produced on their farms is carefully preserved and applied to the land.

The beneficial effects of manure on crop yields are due to its improvement in the chemical, physical and bacteriological soil conditions. It contains considerable amounts of the essential plant food constituents which have been taken out of the soil. It also contains large amounts of organic matter which likewise affects the chemical condition of the soil. The return of plant food constituents by manure means an actual lengthening of the "life" of the soil. In other words it prolongs the time until any of the essential plant food constituents become deficient. If manure is properly stored and does not undergo serious losses of valuable constituents before it is applied to the soil, it may serve in a large measure to keep up the producing power of the soil. The organic matter content not only affects the chemical condition of the soil, but also has a very important effect on the physical conditions. Light, open sandy soils are made more retentive of moisture and plant food and less subject to losses by leaching. Tight heavy clays are opened up and made less impervious and are provided with a better supply of air and moisture. The improved physical conditions in the soil are reflected in a greater production of available plant food and hence may have an important effect on crop yields. Manure contains enormous numbers of bacteria and thru the action of these organisms available plant food is produced. The organic matter content of the manure and the plant food constituents present, serve as food materials for these bacteria and stimulate them to greater action. Hence, the effect of adding manure to soils may be due in many cases to a stimulation in available plant food production thru the actual addition of bacteria and thru an increase in the activities of those already present in the soil. On soils which are high in organic matter, the beneficial effects of small applications of manure is probably due mainly to the influence on bacteria. On newly drained areas where the soil is rich, small amounts of manure have been found to produce large effects and these are undoubtedly attributable to the bacteria introduced. On most soils, however, the beneficial effects of manure are probably due to a combination of chemical, physical and bacteriological effects.

On the farms manure is very often looked upon as a waste material to be disposed of with the least amount of labor. Too often it is stored in loose piles exposed to the weather and subject to the washing action of the rain and alternate wetting and drying. In such cases, 70 to 90 percent of the valuable constituents of manure may be lost before it is applied to the soil and the beneficial influence on crop growth is correspondingly reduced. Losses from manure thru improper storage therefore mean actual money losses on the farm and the farmer who does not take proper care of the manure produced is wasting one of his most valuable assets. Various methods are followed in storing manure and no one method can be recommended for use under all conditions. The man-

ure may be stored in a covered yard or in a pit. It may be composted or it may merely be protected from the weather, or some other method may be employed. Whatever plan is followed it should be emphasized that manure should be kept moist and compact and protected from the weather. In some cases the manure may be applied to the soil as it is produced, and when this is possible there is no storage problem. Frequently however, it must be stored and then some method must be chosen which will keep the losses down to the lowest possible point. Even under the very best conditions of storage manure undergoes some changes which are undesirable. But when carefully stored and applied to the soil it is estimated that as much as 75 percent of the valuable plant food constituents removed from the soil by the crops grown may be returned.

The production of manure on the average livestock farm is insufficient to provide for any large applications to all the soils of the farm. Often it is not possible even to make the usual 8 to 10 ton application once in a four year rotation. Occasionally larger amounts are used with profitable effects, but in general the smaller applications yield greater crop effects per ton of manure applied. In any case, however, it is not desirable to apply more than 16 to 20 tons per acre to Iowa soils for general farm crops. It is most desirable that manure be applied at regular intervals to the soils on the farm and to do this reasonable amounts must be employed. Smaller applications than the normal amounts mentioned above may be made to the darker colored types and to newly drained areas. On such soils the manure should not be applied immediately preceding the small grain crop owing to the danger of causing it to lodge. The application in such cases should be made at some other point in the rotation and it will then have no undesirable effects. The large beneficial effects on all farm crops have been indicated in the experiments given earlier in this report and similar results have been secured thruout the county by much practical farm experience. No other fertilizing material will give as large returns as manure, and unless manure is applied as a basic soil treatment, applications of other fertilizers are apt to be of little effect.

On the grain farm some other fertilizing material supplying organic matter must be utilized in place of farm manure and serve as a basic soil treatment. On many livestock farms where the supply of manure is insufficient for all the soils, there is likewise a need for something to supplement the manure. In both cases green manuring is a desirable practice. Legumes or non-legumes turned under in the soil are known as green manures. Legumes are much preferable for use in this way because of the fact that they are able, when well inoculated to utilize the free nitrogen of the atmosphere and fix it in the soil where it becomes of use to subsequent crops. For this reason legumes as green manures not only supply organic matter to soils but they add considerable amounts of nitrogen and serve as a nitrogenous fertilizer, having therefore a double value. Non-legumes supply only organic matter and while their use may be desirable in some instances, it is rarely that some legume could not be used with more beneficial effects. Many legumes are available for use as green manures and it is possible therefore, to select one which will be suitable for almost any climatic, soil or rotation condition.



Green manuring is often a very desirable practice on the livestock farm and on the grain farm it is absolutely necessary if the organic matter content of the soil is to be maintained. Many of the soils of Fayette county might be improved thru the judicious use of a leguminous green manure. The practice should not be followed blindly nor carelessly, however, as it may lead to undesirable effects. Thus, turning under a heavy green crop in a dry season may cause undesirable effects on the succeeding crop because of interference with moisture conditions. The turning under of a part of the clover crop in the rotation is a partial green manuring practice which is very desirable. Frequently only the clover seed is removed and the remainder of the crop is plowed under. Then large beneficial effects may be secured. Sometimes the first crop is harvested and the second crop is plowed under. By this method of course a much smaller effect on the soil conditions is secured. Sometimes a legume may be seeded in the corn at the last cultivation and serve as a catch crop. Occasionally some legume may be utilized as a cover crop, and in both instances beneficial effects may result in the soil because of the turning under of the green material. Advice regarding green manuring under special soil conditions will be given by the Soils Section upon request.

The utilization of crop residues produced on the farm is very necessary in order to aid in keeping up the supply of organic matter. Such materials as straw and stover also contain considerable amounts of plant food constituents and hence they aid in keeping up the fertility of the soil. Their chief value, however, lies in their effect on the organic matter content of the soil. Too often these residues are burned or otherwise destroyed and there is a loss of valuable material from the farm. On the livestock farm they should be used for feed or bedding and returned to the soil in the manure. On the grain farm they may be applied directly to the soil, or the straw may be allowed to decompose partially before being plowed under. It is particularly important that these materials be thoroly utilized on the grain farm because of a lack of farm manure but they should not be wasted on the livestock farm, as it is quite as necessary under this type of farming to use all precautions to keep up the supply of organic matter and plant food constituents in the soil.

### THE USE OF COMMERCIAL FERTILIZERS

The soils of Fayette county are quite generally low in phosphorus and phosphorus fertilizers are undoubtedly necessary in many instances for the most satisfactory crop production at the present time. In any case they will be needed in the near future as the total supply is inadequate for any large number of crops. Even if the total amount of phosphorus in the soils were large there would be no assurance that there was a sufficient production of available phosphorus. If bacterial activities are not at the best because of poor physical conditions or for other reasons, insufficient phosphorus may be changed to an available form to supply crop needs. In such cases an available phosphorus fertilizer may give crop increases. However, when the total amount of phosphorus is as low as is the case in many of the soils of this county, there can be little question but that there is a lack of the element in an available form. With smaller

amounts of phosphorus in the soil disproportionately smaller amounts are changed to an available form. In the soils of Fayette county with the exception of the Clyde silty clay loam, the Bremer loam and the Wabash soils on the bottoms, the phosphorus supply is so low that there is quite probably a need for phosphorus fertilization. The evidences from the greenhouse and field tests reported earlier point to the desirability of testing phosphorus fertilizers in this county to determine their value. The indications are that they may prove distinctly profitable in many instances. They will certainly be needed in the near future and the securing of unsatisfactory crops at the present time may be an indication of phosphorus needs.

There are two phosphorus fertilizers which may be employed, rock phosphate and acid phosphate. Acid phosphate contains phosphorus in an available form while rock phosphate does not, or at least it has only a low rate of production of available phosphorus. Acid phosphate costs more than the rock but should be supplied in smaller amounts and more frequently. Thus the rock is used at the rate of 2,000 pounds per acre once in a four year rotation, while the acid phosphate is applied at the rate of 200 pounds per acre annually. The field experiments which are being carried out include tests of both of these materials and eventually it may be possible to determine which can be used with the greatest profit on the particular soil types. The results given earlier in this report show some comparisons of the two phosphates and while they indicate some superior effects for acid phosphate, definite conclusions should not yet be drawn. Sufficient data is hardly available to permit of a positive choice between the two materials. It is urged that farmers test the value of both the rock phosphate and the acid phosphate on their own soils and thus determine which material would be the most profitable for their particular conditions. Testing these materials on the farm is comparatively simple and farmers may obtain directions for the carrying out of such tests from Circular 82 of the Iowa Agricultural Experiment Station.

The nitrogen content in the soils of Fayette county is not low except in a few instances in some of the minor sandy types, but this element must be taken into account in planning for systems of permanent fertility. Nitrogen is constantly disappearing from soils thru assimilation by plants and washing away in the drainage water, and some material must be used to make up for these losses. Farm manure if properly cared for and applied to the soil aids considerably in keeping up the nitrogen content. But this material alone is not sufficient even on the average livestock farm to maintain the supply. Under such farming conditions and more especially on the grain farm where farm manure is not available, nitrogen must be supplied. The cheapest and best nitrogenous fertilizer to employ is a leguminous green manure, and by the proper growth and turning under of well inoculated legumes the nitrogen supply in the soil may be quite readily maintained. If the legume crop of the rotation is utilized in part at least as a green manure and inoculation has been practiced there may be some addition of nitrogen to the soil. If the crop is removed for hay, however, there will be no gain in nitrogen. Hence if the content of this element in the soil is to be increased and kept up all of the legume grown in the rotation must be

plowed under or the major part of it incorporated with the soil, or some legume must be used as a catch crop or as a cover crop. The thoro use of all crop residues also has an important effect on the maintenance of the nitrogen content of soils and they serve to a certain extent as a nitrogenous fertilizer. Commercial nitrogenous fertilizers cannot be recommended for general farm crops on the soils of this county at the present time. Possibly they may be applied in small amounts as top dressings but leguminous green manures are less expensive and quite as satisfactory for general use. There is no objection to the application of commercial nitrogen, however, if tests are made and the particular material gives definite evidence of value. Such materials should be tested on small areas before any large acreage is treated.

The soils of the state have shown, according to analyses, a large content of potassium in practically all cases. It would not be expected, therefore, that there would be any general need for the application of a potassium fertilizer, for general farm crops. If proper physical conditions are maintained in the soil with abundance of organic matter and an adequate moisture content, sufficient available potassium should be produced to supply the needs of crops for many years to come. There may be cases where sufficient potassium is not being changed to an available form and where this is true a soluble potassium fertilizer might prove valuable. Such materials cannot be recommended, however, at the present time as there is no evidence available to show that they will prove profitable. Tests should be made on small areas before there is any application to a large area. Occasionally small amounts of potassium fertilizers may be applied as top dressings in order to stimulate the early growth of some crop, but in general commercial potassium cannot be recommended for use on the soils of this county unless tests have been carried out and have shown profitable returns.

Complete commercial fertilizers are probably unnecessary on many of the soils of this county. It would seem from the experiments reported earlier that quite as beneficial effects may be secured from the use of acid phosphate. This would indicate that the nitrogen and potassium contained in the complete fertilizer had little effect or at least no profitable effect. Complete commercial fertilizers are much more expensive than phosphates and must bring about, therefore, much larger increases if they are to prove profitable. The evidence from the experimental results would point to the fact that phosphorus fertilizers will be of much more use in this county than any complete brands of commercial fertilizer. Nitrogen may be more cheaply supplied in leguminous green manures, and the proper supply of available potassium may be secured thru a proper handling of the soil. It is hardly logical, therefore to expect large increases or large profits from the use of complete fertilizers. There may be instances where they would prove profitable and when this is true there is no objection whatever to their use. Farmers who are interested should test these materials on small areas and if they secure more profitable effects than by the use of acid phosphate then they may employ the complete brands. Until such tests are available, however, it is not recommended that complete fertilizers be used with the expectation of securing profitable crop increases.

## DRAINAGE

Some of the soils in Fayette county are not adequately drained and hence are not producing the most satisfactory crops. The natural drainage system in the county is quite adequate as was indicated in the drainage map given earlier in the report, but there are small areas of various soils which would be very much improved by tiling. The Clyde silty clay loam is particularly in need of drainage and there are limited areas of some of the other upland types which are in need of tiling. On the terraces, the Bremer loam is not adequately drained and in some areas the Waukesha loam would be benefitted by tiling. The Wabash soils of the bottoms are too wet but they are in need of protection from overflow as well as in need of tiling.

Wherever soils are too wet, crop production is unsatisfactory and no method of soil treatment with natural or artificial fertilizers will give any large effects on wet soils. Drainage is a fundamental treatment on many soils, and it is particularly needed in the Clyde silty clay loam in this county. The cost of tiling may be considerable but the expense involved is more than warranted by the increased value of the crops secured. Tiling out many small areas in Fayette county may lead to more profitable crop growth, and must be looked upon as a fundamental treatment in planning for the permanent fertility of the soils of the county.

## THE ROTATION OF CROPS

Some good rotation should be adopted on all soils since soils under continuous cropping rapidly become depleted in fertility. Many experiments and much farm experience have demonstrated the superior value of a rotation of crops over a continuous system and that it is neither profitable nor economic to grow one crop continuously. Many rotations are used with satisfactory results and no rotation can be said to be the best for all conditions. A good rotation contains a legume for the reason that leguminous residues are of value in keeping up the nitrogen and organic matter content of the soil.

The following are a few of the rotations which might be suggested for this section of the corn belt. They may be modified according to the special needs of the farmer. In all of these proposed rotations where clover is designated, it is understood that the crop may be red, mammoth, alsike, sweet or Hubam clover. Farmers should make a special effort to determine the value of sweet clover and of Hubam as green manure crops in their rotation programs:

### 1. SIX-YEAR ROTATION

First year—Corn

Second year—Corn

Third year—Wheat or oats (with clover, or clover and grass)

Fourth year—Clover, or clover and grass

Fifth year—Wheat (with clover), or grass and clover

Sixth year—Clover, or clover and grass

It should be clearly understood that there should be as many fields as there are years in the rotation. The six-year rotation outlined above may be of special value in southern and western Iowa where winter wheat is grown more extensively than elsewhere in the state. On a grain farm, the clover grown in the

rotation may serve as a partial green manure if the first crop is harvested and the second crop is plowed under. A better practice from a fertilizer standpoint, is to remove only the clover seed, plowing under all of the rest of the crop. This can be done if the first crop is clipped and left on the ground and the straw from the hulling machine is spread on the field before the land is plowed for the following grain crop.

This rotation may be reduced to a five-year rotation by cutting out either the second or sixth year and to a four-year rotation by omitting the fifth and sixth years.

## II. FOUR OR FIVE-YEAR ROTATION

First year—Corn  
 Second year—Corn  
 Third year—Wheat or oats (with clover or with clover and timothy)  
 Fourth year—Clover (If timothy was seeded with the clover the preceding year, the rotation may be extended to five years. The last crop will consist principally of timothy.)

## III. FOUR-YEAR ROTATION WITH ALFALFA

First year—Corn  
 Second year—Oats  
 Third year—Clover  
 Fourth year—Wheat  
 Fifth year—Alfalfa (The crop may remain on the land five years. This field should then be used for the four year rotation outlined above and the alfalfa shifted to one of the fields which previously was in the four-year system.)

## IV. FOUR-YEAR ROTATIONS

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

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

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

## V. THREE-YEAR ROTATIONS

First year—Corn  
 Second year—Oats or wheat (with clover seeded in the grain)  
 Third year—Clover (In grain farming, only the grain and clover seed should be sold; most of the crop residues such as corn stover and straw should be plowed under. The clover may be clipped and left on the land to be returned to the soil and only the seed taken from the second crop.)

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

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

### THE PREVENTION OF EROSION

Erosion is the carrying away of soil thru the free movement of water over the surface of the land. If all the rain falling on the ground were absorbed, erosion could not occur, hence it is evident that the amount and distribution of rainfall, the character of the soil, the topography or the "lay of the land," and the cropping of the soil are the factors which determine the occurrence of this injurious action.

Slowly falling rain may be very largely absorbed by the soil, provided it is not already saturated with water, while the same amount of rain in one storm will wash the soil badly. When the soil is thoroly wet, the rain falling on it will of course wash over it and much of the soil may be carried away in this manner to the detriment of the land.

Light, open soils which absorb water readily are not apt to be subject to erosion while heavy soils such as loams, silt loams and clays may suffer much from heavy or long-continued rains. Loess soils are very apt to be injured by erosion when the topography is hilly or rough and it is this group of soils which is affected to the greatest extent in Iowa. Flat land is, of course, little influenced by erosion. Cultivated fields or bare bluffs and hillsides are especially suited for erosion while land in sod is not affected. The character of the cropping of the soil may therefore determine the occurrence of the injurious action.

The careless management of land is quite generally the cause of the erosion in Iowa. In the first place, the direction of plowing should be such that the dead furrows run at right angles to the slope; or if that is impracticable, the dead furrows should be "plowed in" or across in such a matter as to block them. Fall plowing is to be recommended whenever possible as a means of preventing erosion. Only when the soil is clayey and absorption of water is very slow will spring plowing be advisable. The organic matter content of soils should be kept up by the addition of farm manure, green manures and crop residues if soil subject to erosion is to be properly protected. By the use of such materials the absorbing power of the soil is increased and they also bind the soil particles together and prevent their washing away as rapidly as might otherwise be the case. By all these treatments the danger of erosion is considerably reduced and expensive methods of control may be rendered unnecessary.

There are two types of erosion, sheet washing and gulying. The former may occur over a rather large area and the surface soil may be removed to such a large extent that the subsoil may be exposed and crop growth prevented. Sheet washing often occurs so slowly that the farmer is not aware of the gradual removal of fertility from his soil until it has actually resulted in lower crop yields. Gulying is more striking in appearance but it is less harmful and it is usually more easily controlled. If, however, a rapidly widening gully is allowed to grow unchecked an entire field may soon be made useless for farming purposes. Fields may be cut up into several portions and the farming of such tracts is more costly and inconvenient.

In Fayette county erosion occurs to some extent in the Carrington loam, the main soil type. The soils in the Lindley series are all badly eroded and in fact have been formed and are distinguished because of the serious erosion to which

they have been subjected. The Fayette silt loam is very seriously washed and much of the surface material has been carried away. Occasionally some erosion occurs in the Tama silt loam. There is little erosion on the terraces but some washing has occurred in the higher, older terraces. It is very important, therefore, that means be taken to protect these various soils from the continued carrying away of valuable surface soil.

The means which may be employed to control or prevent erosion in Iowa may be considered under five headings as applicable to "dead furrows" to small gullies, to large gullies, to bottoms, and to hillside erosion.

#### EROSION DUE TO DEAD FURROWS

Dead furrows or back furrows, when running with the slope or at a considerable angle with it, frequently result in the formation of gullies.

*"Plowing In."* It is quite customary to "plow in" the small gullies that result from these dead furrows and in level areas where the soil is deep, this "plowing in" process may be quite effective. In the more rolling areas, however, where the soil is rather shallow, the gullies formed from dead furrows may not be entirely filled up by "plowing in." Then it is best to supplement the "plowing in" with a series of "staked in" dams or earth dams.

*"Staking In."* The method of "staking in" is better as it requires less work and there is less danger of washing out. The process consists in driving in several series of stakes across the gully and up the entire hillside at intervals of from 15 to 50 yards, according to the slope. The stakes in each series should be placed three or four inches apart and the tops of the stakes should extend well above the surrounding land. It is then usually advisable to weave some brush about the stakes, allowing the tops of the brush to point upstream. Additional brush may be placed above the stakes, with the tops pointing upstream, permitting the water to filter thru, but holding the fine soil.

*Earth Dams.* Earth dams consist of mounds of soil placed at intervals along the slope. They are made somewhat higher than the surrounding land and act in much the same way as the stakes in the "staking in" operation. There are some objections to the use of earth dams, but in many cases they may be quite effective in preventing erosion in "dead furrows."

#### SMALL GULLIES

Gullies result from the enlargement of surface drainageways and they may occur in cultivated land, on steep hillsides in grass or other vegetation, in the bottomlands, or at any place where water runs over the surface of the land. Small gullies may be filled in a number of ways but it is not practicable to fill them by dumping soil into them; that takes much work and is not lasting.

*Checking Overfalls.* The formation of small gullies or ditches is practically always the result of overfalls and one of the most important problems is, therefore, the checking of these overfalls and preventing them from working back and extending the size of the gully. An easy method of checking overfalls is to put in an obstruction of straw and brush and stake down with a post. One

or more posts should be set firmly in the ground in the bottom of the gully. Brush is intertwined between the posts, straw is well tramped down behind them and the straw and brush both are held in place by cross pieces nailed to the posts. This method does not fill the existing ditch but does prove very satisfactory for preventing the overfall from working back upstream. It is an installation which is very desirable before any success can be had in filling small or large gullies.

*"Staking In."* The simplest method of controlling small or moderate sized gullies and the one that gives the most general satisfaction is the staking in operation recommended for the control of dead furrow gullies. The stakes should vary in size with the size of the gully, as should also the size and quantity of brush woven about the stakes. A modification of the system of "staking in" which has been used with success in one case consists in using the brush without stakes. The brush is cut so that a heavy branch pointing downward, is left near the top. This heavy branch is caught between a fork in the lower part of the brush-pile, or hooked over one of the main stems and driven well into the ground. Enough brush is placed in this manner to extend entirely across the gully, with the tops pointed downstream instead of upstream, which keeps it from being washed away as readily by the action of a large volume of water. A series of these brush-piles may be installed up the course of the gully and with the regular repair of washouts or undercuttings may prove very effective.

The modification of this system of "staking in" which is being used with success in some sections, consists in covering the bottom and sides of the ditch with straw for a distance of four to ten feet, depending upon the width of the ditch. Brush, ranging in size from fine at the bottom to coarse at the top, is laid on the straw with the butts headed upstream. The brush and straw are held in place by cross pieces spiked to posts previously set. The number of posts will depend of course upon the size of the gully. These posts should be set well into the ground and spaced about four feet apart, being arranged in a V-shape with the point downstream and lower in the center than at the sides of the ditch. This modification of the "staking in" method is proving very satisfactory.

*The Straw Dam.* A simple method of preventing erosion in small gullies is to fill them with straw. This may be done at threshing time with some saving of time and labor. The straw is usually piled near the lower part of the gully, but if the gully is rather long or branching, it should be placed near the middle or below the junction of the branches or more than one dam should be used. The pile should be made so large that it will not wash out readily when it gets smaller thru decomposition and settling. One great objection to the use of straw is the loss of it as a feed, as a bedding material and as a fertilizer. Yet its use may be warranted on large farms which are operated on an extensive scale because of the saving of time, labor and inspection.

*The Earth Dam.* The use of an earth dam or mound of earth across a gully may be a satisfactory method of controlling erosion under some conditions. It will prove neither efficient nor permanent, however, unless the soil above the dam is sufficiently open and porous to allow a rather rapid removal of water by drainage thru the soil. Otherwise too large amounts of water may accumulate above the dam and wash it out. In general it may be said that when not pro-



vided with a suitable outlet under the dam for surplus water the earth dam cannot be recommended. When such an outlet is provided the dam is called a "Christopher" or "Dickey" dam.

*The "Christopher" or "Dickey" Dam.* This modification of the earth dam consists merely in laying a line of tile down the gully and beneath the dam, an elbow or a "T" being inserted in the tile just above the dam. This "T" called the surface inlet, usually extends two or three feet above the bottom of the gully. A large sized tile should be used in order to provide for flood waters and the dam should be provided with a cement or board spillway or run-off to prevent any cutting back by the water flowing from the tile. The earth dam should be made somewhat higher and wider than the gully and higher in the center than at the sides to reduce the danger of washing. It is advisable to grow some crop upon it, such as sorghum, or even oats or rye, and later seed it to grass.

*The Adams Dam.* This dam is practically the same as the Christopher or Dickey dam. In fact the principle of construction is identical. In some sections the name "Adams dam" has been applied and hence it is mentioned separately. This is one of the most satisfactory methods of filling gullies and the dam may also serve as a bridge. The installation of a culvert is generally made of sewer tile with tightly cemented joints and it is recommended that the inlet to the tile be protected from clogging by the installation of posts supporting woven wire. The concrete or plank spill platform is a very important feature of the Adams dam and it is also recommended that an up-stream concrete guard be constructed so that the face of the dam is protected. Taking into account the cost, maintenance, permanence and efficiency, the Adams dam or the Christopher or Dickey dam may be considered as the most satisfactory for filling ditches and gullies, especially the large gullies.

*The Stone or Rubble Dam.* Where stones abound they are frequently used in constructing dams for the control of erosion. With proper care in making such dams the results in small gullies may be quite satisfactory, especially when openings have been provided in the dam at various heights. The efficiency of the stone dam depends rather definitely upon the method of construction. If it is laid up too loosely, its efficiency is reduced and it may be washed out. Such dams can be used only very infrequently in Iowa.

*The Rubbish Dam.* The use of rubbish in controlling erosion is a method sometimes followed and a great variety of materials may be employed. The results are in the main rather unsatisfactory and it is a very unsightly method. Little effect in preventing erosion results from the careless use of rubbish even if a sufficient amount is used to fill the cut. The rubbish dam may be used, however, when combined with the Dickey system, just as the earth dam or stone dam, provided it is made sufficiently compact to retain sediment and to withstand the washing effect of the water.

*The Woven Wire Dam.* The use of woven-wire, especially in connection with brush or rubbish, has sometimes proven satisfactory for the prevention of erosion in small gullies. The woven wire takes the place of the stakes, the principle of construction being otherwise the same as in the "staking in" system. It can only be recommended for shallow, flat ditches and in general other methods are somewhat preferable.

*Sod Strips.* The use of narrow strips of sod along natural surface drainage-ways may often prevent these channels from washing into gullies, as the sod serves to hold the soil in place. The amount of land lost from cultivation in this way is relatively small as the strips are usually only a rod or two in width. Bluegrass is the best crop to use for the sod, but timothy, redtop, clover or alfalfa may serve quite as well and for quick results sorghum may be employed if it is planted thickly. This method of controlling erosion is in common use in certain areas and it might be employed to advantage in many other cases.

*The Concrete Dam.* One of the most effective means of controlling erosion is by the concrete dam, provided the Dickey system is used in connection with it. They are, however, rather expensive. Then, too, they may overturn if not properly designed and the services of an expert engineer are required to insure a correct design. Owing to their high cost and the difficulty involved in securing a correct design and construction, such dams cannot be considered as adapted to general use on the farm.

*Drainage.* The ready removal of excess water may be accomplished by a system of tile drainage properly installed. This removal of water to a depth of the tile increases the water absorbing power of the soil, and thus decreases the tendency toward erosion. Catch wells properly located over the surface and consisting of depressions or holes filled with coarse gravel and connected with the tile help to catch and carry away the excess water. In some places tiling alone may be sufficient to control erosion, but generally other means are also required.

#### LARGE GULLIES

The erosion in large gullies which are often called ravines may in general be controlled by the same methods as in the case of small gullies. The Christopher or Adams dam, already described, is especially applicable in the case of large gullies. The precautions to be observed in the use of this method of control have already been described and emphasis need only be placed here upon the importance of carrying the tile some distance down the gully to protect it from washing. The Dickey dam is the only method that can be recommended for controlling and filling large gullies and it seems to be giving very satisfactory results at the present time.

#### BOTTOMLANDS

Erosion frequently occurs in bottomlands and especially where such lowlying areas are crossed by small streams the land may be very badly cut up and rendered almost entirely valueless for farming purposes.

*Straightening and tiling.* The straightening of the larger streams in bottomland areas may be accomplished by any community and while the cost is considerable, large areas of land may thus be reclaimed. In the case of small streams, tiling may be the only method necessary for reclaiming bottomland and it often proves very efficient.

*Trees.* Erosion is sometimes controlled by rows of such trees as willows which extend up the drainage channels. While the method has some good features it is not generally desirable. The row of trees often extends much further into cultivated areas than is necessary and tillage operations are interfered with.

Furthermore, the trees may seriously injure the crops in their immediate vicinity because of their shade and because of the water which they remove from the soil. In general it may be said that in pastures, bottomlands and gulches the presence of trees may be quite effective in controlling erosion, but a row of trees across cultivated land or even extending out into it, cannot be recommended.

#### HILLSIDE EROSION

Hillside erosion may be controlled by certain methods of soil treatment which are of value, not only in preventing the injurious washing of soils, but in aiding materially in securing satisfactory crop growth.

*Use of Organic Matter.* Organic matter or humus is the most effective means of increasing the absorbing power of the soil and hence it proves very effective in preventing erosion. Farm manure may be used for this purpose or green manures may be employed if farm manure is not available in sufficient amounts. Crop residues such as straw and corn stalks may also be turned under in soils to increase their organic matter content. In general it may be said that all means which may be employed to increase the organic matter content of soils will have an important influence in preventing erosion.

*Growing Crops.* The growing of crops, such as alfalfa, that remain on the land continuously for a period of two or more years is often advisable on steep hillsides. Alsike clover, sweet clover, timothy and red top are also quite desirable for use in such locations. The root system of such crops as these holds the soil together and the washing action of rainfall is reduced to a marked extent.

*Contour Discing.* Discing around a hill instead of up and down the slope or at an angle to it is frequently very effective in preventing erosion. This practice is called "contour discing" and it has proven quite satisfactory in many cases in Iowa. Contour discing is practiced to advantage on stalk ground in the spring, preparatory to seeding small grain, and also on fall plowed land that is to be planted to corn. It is advisable in contour discing to do the turning row along the fence, up the slope, first, as the horses and disc when turning will pack and cover the center mark of the disc, thus leaving no depressions to form a water channel.

*Sod Strips.* The use of narrow strips of sod is very desirable for preventing hillside erosion as well as for the preventing of gully formation. The sod protects the field from the flow of water during rains and prevents the washing away of the surface soil.

*Deep Plowing.* Deep plowing increases the absorptive power of the soil and hence decreases erosion. It is especially advantageous if it is done in the fall as the soil is then put in condition to absorb and hold the largest possible amount of the late fall and early spring rains. It is not advisable, however, to change from shallow plowing to deep plowing at a single operation as too much subsoil may be mixed with the surface soil and the productive power of the soil may therefore, be reduced. A gradual deepening of the surface soil by increasing the depth of plowing will be of value both in increasing the feeding zone of plant roots and in making the soil more absorptive and therefore less subject to erosion.

## INDIVIDUAL SOIL TYPES IN FAYETTE COUNTY\*

There are 22 soil types in Fayette county and these together with the area of muck make a total of 23 separate soil areas. These are divided into five large groups according to their origin and location and these groups are known as drift soils, loess soil, terrace soils, swamp and bottomland soils and residual soils.

### DRIFT SOILS

There are eight drift soils in the county classified in the Carrington, Clyde, Lindley and Thurston series. The total area covered by these drift soils amounts to 62.3 percent of the county.

#### CARRINGTON LOAM (1)

The Carrington loam is the largest individual soil type in the county, covering 42.1 percent of the county. It is the chief upland soil in the western and southern parts of the county, occupying an extensive total acreage but much cut by areas of the Clyde silty clay loam which occur along many of the minor streams and intermittent drainageways. Hence there is no large continuous area of the Carrington loam.

The surface soil of this type is a dark brown loam from 10 to 15 inches in depth. Beneath this point there is a layer of light brown heavy loam to clay loam from four to six inches in thickness. The subsoil is a brownish-yellow, gritty clay loam, sometimes becoming somewhat sandy in the lower part. The subsoil is somewhat plastic when wet but open and friable when dry. On the flatter and depressed areas, the soil is darker in color approaching a black and may vary from a silty loam to a very light textured loam. In the southwest corner of the county it is almost a silty clay loam or clay loam in texture.

In topography the Carrington loam is undulating to gently rolling and it is usually fairly well drained. In some small areas it is level to depressed and in these locations drainage is not entirely satisfactory. The heavier textured areas in the southwestern part of the county are in need of drainage. The type is subject to erosion along the larger streams where the slopes are steeper. In general, however, it is not injured by the formation of gullies or sheet washing to any extent.

About 90 percent of the Carrington loam is now under cultivation. The remainder of the type is in permanent pastures and farmsteads. Corn is the most important crop, being grown on nearly one-half of the type. Yields of corn amount to about 40 bushels per acre. About eighty percent of the corn produced is used for feed on the farms. Oats rank second in acreage and yield 35

\*The descriptions of individual soil types given in this section of the report follow very closely those in the Bureau of Soils report.

<sup>1</sup>Fayette County adjoins Bremer County on the west. In certain cases the soil maps of these counties do not agree along the boundaries. This is due to changes in correlation resulting from a fuller understanding of the soils of the State. The Fargo loam in Bremer County has been changed to Clyde silty clay loam in this county. The Bremer sandy loam in Bremer County is divided into the O'Neill loam and the Plainfield loam. Meadow, in Bremer County, has in this area been mapped with the Wabash loam or the Cass fine sandy loam. (Bur. Soil Report.)



Fig. 6. Gently undulating topography of the Carrington soil.

to 40 bushels per acre. Probably about 70 percent of the oats produced is used for feed on the farm. Barley is grown to some extent and yields 30 to 35 bushels per acre. Clover and timothy are grown for hay and yield  $1\frac{1}{2}$  to 2 tons per acre. Some timothy is grown for seed. Very little wheat is produced and potatoes are not grown on this type to any extent.

The Carrington loam is a fairly productive type and in general crop yields are quite satisfactory. Much larger yields may be secured, however, thru proper methods of soil treatment. On the small, level areas where drainage is poor, tiling should be practiced and on the steeper slopes along the streams some method should be followed to protect the type from erosion. In general the soil is not in need of these treatments, however. The type responds very profitably to the application of farm manure and the data given earlier in this report gives definite evidence in support of this statement. The average results for all the fields on this type should be noted particularly. Much larger increases in crops are often secured, however, in individual cases on this type. There is no question of the desirability of applying farm manure to the Carrington loam in liberal amounts and profitable increases in crop yields may thus be secured. The type is acid and should be limed if satisfactory crop yields are to be secured, particularly of legumes. The tables already referred to give evidence of the beneficial effect of liming on this type. Phosphorus fertilizers are undoubtedly necessary in many cases on this soil and the experimental work thus far available shows that a phosphorus carrier may often be applied with profitable effects. There is evidence of somewhat superior value for acid phosphate but the evidence is not entirely conclusive as it is not felt that the data has been secured over a long enough period of years. It is urged, therefore, that farmers test

the use of both rock phosphate and acid phosphate on their own soils and thus determine for their own conditions which material can be most profitably employed.

#### CLYDE SILTY CLAY LOAM (85)

The Clyde silty clay loam is the second largest drift soil in the county covering 15.4 percent of the total area. It occurs thruout the western and southern parts in association with the Carrington loam of the upland. It is found in depressions and narrow strips along the smaller streams and intermittent drainage-ways on the uplands, and practically every 40 acres of the Carrington loam is characterized by the occurrence of one or more narrow areas of the Clyde silty clay loam.

The surface soil of the type is a black silty clay loam 15 to 18 inches in depth, containing some fine sand. This grades gradually into a dark gray plastic clay loam subsoil mottled with yellow and rusty brown. Below 20 to 24 inches the color becomes a light gray and the mottlings somewhat brighter. Frequently a yellow, gravelly, sandy loam appears in the lower part of the three foot section. Boulders and stones of all sizes occur thruout the soil and at the surface. There are many small areas of the loam, occurring along the edges of the larger areas and sometimes alone, where the texture is a loam, but the Clyde loam has not been mapped separately owing to the irregular occurrence and small extent of these areas. In topography the type is flat to depressed and drainage is very poor. The first treatment needed to make this soil satisfactorily productive is the installation of tile.

The larger part of the type is in grass which is used for hay or pasture and only about five percent is under cultivation. Corn is grown on the cultivated areas yielding 40 to 60 bushels per acre. Hay produces 2 to 3 tons per acre. Grain crops make a rank growth and are apt to lodge. When the type has been thoroly drained, crop yields may be very much increased. Small amounts of farm manure will undoubtedly be of value on newly reclaimed areas. The type is acid and in need of lime if legumes are to be grown. It is fairly well supplied with phosphorus at present but will undoubtedly need phosphorus fertilizers in the near future. Small applications of acid phosphate might prove of value at the present time.

#### LINDLEY LOAM (65)

The Lindley loam is a minor drift type in the county, covering only 1.7 percent of the total. It occurs in small widely scattered areas in the central and western portions of the county in association with the Carrington loam. The largest individual area is in the northwestern corner of the county near Waucoma, along the Little Turkey river. Other areas occur east of St. Lucas along Bass Creek and a mile and a half north of West Auburn. Rather extensive areas occur along the Wapsipinicon river from Fairbank north, and along the Volga river around Fayette and west for several miles. There is a small area on the western boundary of the county along the Little Wapsipinicon river and several small areas along Crane creek in the northwestern part of the county.

The surface soil of the Lindley loam is a light brown or brownish-gray loam



Fig. 7. Turkey River bottoms from Eldorado hill. Town of Eldorado in the distance.

extending to a depth of 6 inches. The subsoil is a brownish-yellow gritty clay loam mottled with light gray below 30 inches. There is considerable sand and fine sand in the surface soil and some areas of soil of these textures are included with the type because of their small extent. In the area north of West Auburn the type is silty in texture and apparently has been considerably modified by the adjacent loess.

In general the topography of the type is gently sloping. It is well drained and only in local areas is it subject to serious erosion. It has been developed in timbered areas along stream courses and adjacent to timbered loessial soils, but most of the type has been cleared and is now used for the production of general farm crops. Corn, oats, barley, and clover and timothy are grown on this type with fair yields. Crops may be considerably increased thru proper methods of soil treatment and applications of farm manure are particularly desirable as the soil is low in organic matter. If farm manure is not available, then leguminous crops should be used as green manures. The type is acid and in need of lime which must be employed if legumes are to be successfully grown. The phosphorus content is low and applications of phosphorus fertilizers will undoubtedly be needed in the future and may be of large value at the present time.

#### LINDLEY SANDY LOAM (161)

This is a minor type in the county, covering 1.0 percent of the total area. It occurs in small isolated areas along the slopes and drainageways. The largest area is four miles northwest of Clermont, along the Turkey river. Other minor areas occur along the Turkey river, especially in the vicinity of

Elgin. Small areas also occur along the Volga river near Fayette, along Otter creek, Bass creek and Crane creek.

The surface soil of the Lindley sandy loam is a light brown sandy loam 6 to 8 inches in depth containing a considerable amount of coarse sand. The subsoil is a friable loamy sand or sand of a brownish-yellow color. In topography the type is usually gently rolling, but some of the areas, particularly along Turkey river, are rather steep. Drainage is excessive and the land is inclined to be drouthy. It has been modified considerably by erosion and is still subject to extensive gullying and washing.

The Lindley sandy loam was originally forested but about 75 percent is now under cultivation, the remainder being in pasture. Corn, oats, clover and timothy are the chief crops grown. Corn yields 20 to 40 bushels per acre,, oats 20 to 35 bushels and timothy and clover one to two tons of hay. Watermelons and truck crops do well and excellent yields of potatoes are frequently secured. The cultivated portions of this type may be made much more productive thru proper methods of soil treatment. The type will respond to liberal applications of farm manure and leguminous crops may often be used profitably as green manures. The type is particularly in need of organic matter. It is acid in reaction and should be limed if legumes are to be grown. It is low in phosphorus and phosphate fertilizers would probably prove of considerable value in many cases. The steep slopes of the type should not be cultivated but are preferably kept in pasture. Erosion is very active in such areas and serious washing occurs when the steeper slopes are cultivated.

#### LINDLEY FINE SANDY LOAM (136)

The Lindley fine sandy loam is a very minor type in the county covering 0.8 percent of the total. It occurs in several small areas along the streams, the largest occurring around St. Lucas, northwest of West Auburn and along the Volga river, both north and southeast of Lima. Many other smaller areas occur along other streams.

The surface soil of the Lindley fine sandy loam is a light brown in color and extends to a depth of about eight inches. The subsoil is a brownish-yellow fine sandy loam to loamy sand in the upper part, grading into a yellow fine sandy loam to loamy fine sand below 30 inches. Frequently the surface soil contains considerable silt which has been brought in from the surrounding loessial areas. In topography the type is rolling to steeply rolling and drainage is excessive. It is subject to erosion and may be very badly washed if not properly handled.

The type was originally forested. About 75 percent, however, has been cleared and brought under cultivation, corn, oats and hay being the most important crops grown. The yields are very much the same as those secured on the Lindley sandy loam. The type is particularly in need of organic matter. to make it more productive. Liberal applications of farm manure should be made or leguminous crops should be used as green manures. The type is acid and in need of lime. It is low in phosphorus and will certainly respond to applications of phosphorus fertilizers.





Fig. 8. Broad bottoms of Little Turkey River in the northern part of the county.

#### CARRINGTON SANDY LOAM (3)

The Carrington sandy loam is a minor type in the county covering only 0.6 percent of the total area. It occurs in several areas, being the best developed in the vicinity of Wadena, south of Fayette and north of Elgin. The largest area is west of Wadena. Numerous other small areas occur in various parts of the county.

The surface soil of the type is a dark brown to black loam extending to a depth of 12 inches. The subsoil is a brown clay loam, grading at about 18 inches into a yellowish-brown clay loam. In most of the areas as mapped in this county, the subsoil is a brownish-yellow to yellow rather coherent sand. Only in the area south of Fayette is a typical subsoil developed. In topography the soil is gently sloping, occurring on low hills and ridges along stream courses. Drainage is thoro and often excessive.

About 90 percent of the Carrington sandy loam is under cultivation, the remainder being in permanent pasture. Yields of corn are secured amounting to 25 bushels per acre, oats 20 to 25 bushels and clover and timothy one to two tons per acre. This soil is particularly in need of organic matter if it is to be made more productive and it should receive liberal amounts of farm manure or leguminous green manure crops should be turned under. It is acid in reaction and should be limed if legumes are to make the most satisfactory growth. It is low in phosphorus and will need phosphorus fertilizers for the best growth of cultivated crops. It is subject to some erosion and must be protected from serious washing.

## THURSTON SANDY LOAM (162)

The Thurston sandy loam is a very minor type in the county, covering 0.5 percent of the total area. It occurs chiefly in the vicinity of the Little Turkey river. The forested areas occur southwest of Waucoma, and north of the river. The prairie areas are found chiefly south of the river and are small in area.

The surface soil of the type in the prairie areas is a black sandy loam 6 to 8 inches deep while in the timbered regions it is a light brown sandy loam 4 to 6 inches in depth. In both cases the subsoil is a gravel, yellowish-brown to rusty brown in color.

The topography of the type is described as bumpy, consisting of alternating knobs and depressions. It is extremely drouthy and only a small part of it is under cultivation. The uncultivated areas are used for pasture. This type is particularly in need of organic matter if crops are to be grown and it should receive liberal applications of farm manure or leguminous crops as green manures. It is acid in reaction and in need of lime. It is low in phosphorus and would respond to phosphorus fertilization.

## CARRINGTON FINE SANDY LOAM (4)

The Carrington fine sandy loam is of very minor occurrence in the county covering only 0.2 percent of the total area. It occurs in numerous small areas in association with the Carrington loam in the southern and western parts. The best developed area is directly south of St. Lucas. Many small patches of this type are not shown separately on the map owing to their small extent.

The surface soil of the type is a fine sandy loam dark brown to black in color and 10 to 12 inches in depth. It is underlaid by a brown fine sandy loam passing abruptly into a grayish-yellow loamy fine sand. It occurs on gentle slopes, low hills and ridges, and drainage is adequate and sometimes excessive. The type is subject to some erosion.

Most of the Carrington fine sandy loam is under cultivation, the same crops being grown as on the Carrington loam, but the yields are lower, however, than on the loam. The type is particularly in need of organic matter and should receive liberal applications of farm manure or leguminous green manure crops if it is to be made most satisfactorily productive. It is acid in reaction and needs liming. It is low in phosphorus and would respond to phosphorus fertilizers.

**LOESS SOILS**

There are two loess soils in the county, classified in the Fayette and Tama series and together they cover 27.3 percent of the total area.

## FAYETTE SILT LOAM (163)

The Fayette silt loam is the second largest soil type in the county and the largest of the loess soils, covering 20.3 percent of the total area. It occurs in extensive areas on the uplands in the northeastern part of the county, in association with the Tama silt loam. In fact the entire upland area in that part of the county is occupied by these types.



Fig. 9. Fayette silt loam topography.

The surface soil of the Fayette silt loam is a light grayish-brown, friable smooth silt loam, 6 to 8 inches in depth. The subsoil is a brownish-yellow silt loam to silty clay loam, mottled with light gray in the lower part. The soil varies considerably in depth and color. On the upper part of steep slopes, it is a light yellowish-gray in color and much shallower. On the more level areas between drainageways, on the lower slopes of hills and in forested areas the soil is brown and sometimes dark brown. In these areas the type is deeper.

In topography the soil is steeply rolling to hilly or broken. It occurs on the steep slopes to valleys which are 300 to 400 feet in depth. The wide irregularities of the underlying rock formations upon which the loess was deposited gives the type a very rough, irregular topography, with few level areas. Drainage of the type is excellent. It is subject to severe erosion in practically all areas and needs to be handled carefully to keep the surface soil from washing away.

Practically all the type was originally forested with oak, maple, elm, hickory, walnut, cherry, basswood, cottonwood, ironwood, pine, cedar and willow. About 80 percent is now under cultivation and general farm crops are grown. Corn yields 35 to 45 bushels per acre, oats, 35 to 40 bushels, barley, 25 to 35 bushels, and clover and timothy  $1\frac{1}{2}$  to  $2\frac{1}{2}$  tons. Near Elgin some sweet corn is grown, yielding from 3 to 5 tons per acre. Apples and small fruits do well. A considerable acreage of the type is utilized for pasture.

The Fayette silt loam is in need particularly of protection from erosion if it is to be made and kept more productive. It is very low in organic matter, and should receive liberal applications of farm manure. Legumes should be used as green manures when farm manure cannot be applied in sufficient amounts and all crop residues should be thoroly utilized. The type is acid and must be limed if the best growth of legumes is to be secured. It is low in phosphorus and applications of phosphorus fertilizers will undoubtedly prove

of value. On the steeper slopes the land should be kept in sod or pasture and many areas should be kept in grass as much of the time as possible. Very satisfactory crop yields may be secured, however, on the less broken areas if proper fertilization is practiced.

#### TAMA SILT LOAM (120)

The Tama silt loam is the fourth largest soil type in the county and the second loess soil, covering 7.0 percent of the total area. It occurs on the uplands in the northeastern part of the county in association with the Fayette silt loam. It is found on the more level upland areas thruout the loessial region. The largest areas occur north of West Union, northeast of Arlington, east of Fayette, and on the more level upland, halfway between the Volga river and Otter creek.

The surface soil of the Tama silt loam is a dark brown, moderately heavy, smooth textured silt loam, 10 to 15 inches in depth. Below this point there is a layer of brown silt loam, 4 inches thick, which grades into a brownish-yellow heavy silt loam to light silty clay loam, becoming yellow in color at the lower depths and sometimes slightly mottled with light gray. The type varies somewhat in depth. On the more gently rolling areas it is 15 to 18 inches deep while on the hillsides and along gullies it is only 6 to 8 inches in depth and the yellowish-brown subsoil is often exposed. At the base of slopes, it is darker in color and may be 24 inches deep. Small narrow strips of colluvial material occurring in such areas are included with the type. The boundary between the Fayette silt loam and the Tama is often drawn arbitrarily as there is apt to be a gradual change from one type to the other.

In topography the Tama silt loam is gently rolling to rolling. Drainage is quite adequate. On the steeper slopes, some erosion occurs but the type is not often subject to washing.

About 95 percent of the Tama silt loam is now under cultivation, corn being the chief crop grown. About one-third of the type is devoted to this crop, yields of 30 to 50 bushels per acre being secured. Oats rank second in acreage and yield 35 to 45 bushels per acre. About one-fourth of the corn and oats is sold, the remainder being fed on the farms. Clover and timothy are the principal hay crop, yielding 1 to 2 tons per acre. Clover alone yields 1½ to 2½ tons, and is grown to some extent. Some millet, sorghum, wheat and rye are also grown.

This soil is naturally highly productive but crop yields may be increased by proper soil treatments. Farm manure brings about good effects on crops as has been shown in the greenhouse and field tests discussed earlier in this report. The soil is acid and in need of lime. It will respond to phosphorus fertilizers and farmers should test the value of rock phosphate and acid phosphate on their own land to determine which material will give the best results.

#### TERRACE SOILS

There are seven terrace soils in the county, classified in the O'Neill, Plainfield, Bremer, Jackson and Waukesha series. They are all small in area, together covering 5.7 percent of the total area of the county.

## O'NEILL LOAM (108)

The O'Neill loam is the largest of the terrace soils, covering 3.2 percent of the total area of the county. It occurs in narrow strips along the various streams. The largest areas occur along the Volga river and the Little Volga river in the vicinity of Maynard and to the north. There are also rather extensive areas near Alpha along Crane creek. Many other small areas occur along various streams in all parts of the county.

The surface soil of the O'Neill loam is a dark brown to black loam 12 to 15 inches in depth. In places it contains considerable sand. The subsoil is a brown heavy loam, becoming brownish-yellow and lighter in texture at 20 inches and below 24 to 30 inches it changes to a coarse sand or fine gravel, brown in color. The gravel layer sometimes occurs at 8 to 12 inches from the surface and in other cases at a depth of 3 to 4 feet. In topography the soil is level, the land laying 5 to 20 feet above the present flood plains. Drainage is thoro and the type is droughty.

About 95 percent of the O'Neill loam is under cultivation, corn being the principal crop grown. Yields of 25 to 40 bushels per acre are secured but in dry seasons the crop may be seriously injured. Oats yield 20 to 40 bushels per acre and clover and timothy 1 to 1½ tons of hay per acre.

The O'Neill loam is particularly in need of organic matter if it is to be made more productive and less subject to drought. Liberal amounts of farm manure should be applied and legumes should be used as green manures. The type is acid in reaction and should be limed to insure good legume growth. It is low in phosphorus and would undoubtedly respond to phosphorus fertilizers.

## PLAINFIELD LOAM (16)

The Plainfield loam is minor in area in the county, covering only 1.0 percent of the total. It occurs in many small narrow areas along the streams. The largest development of the type is along the Wapsipinicon river and Otter creek in the southwestern part and along the Little Turkey river near Waucoma. Numerous other small areas occur in other parts of the county.

The surface soil of the Plainfield loam is a grayish-brown friable loam, 6 to 10 inches in depth, containing much fine sand and silt. The subsoil is a brownish or light yellow loam which at 18 to 30 inches passes into sand and gravel.

In topography the type is level to flat and drainage is excessive. It lies on terraces 10 to 15 feet above the normal flow of the streams and hence is not subject to overflow.

Originally the soil was forested with white oak, red oak, hickory, elm, basswood and ash. About 90 percent of the type is now utilized for general farm crops, corn, oats, clover and timothy. Corn yields 30 to 50 bushels per acre and oats 25 to 35 bushels.

The Plainfield loam is in need of organic matter to make it more productive and less subject to injury by drought. Farm manure should be applied in large amounts, leguminous green manures should be used and all crop residues turned under. The type is acid and in need of lime. It is low in phosphorus and would undoubtedly respond to phosphorus fertilizers.

## BREMER LOAM (12)

The Bremer loam is a minor type in the county covering only 0.4 percent of the total area. It occurs chiefly northwest and southeast of Maynard along the Little Volga river. Other smaller areas occur in other parts of the county.

The surface soil of the Bremer loam is a black friable loam, 14 to 18 inches in depth. The subsoil is a plastic, tenacious, bluish-gray clay loam, mottled with rusty brown and yellow. In some areas sand and gravel are found in the lower part of the three foot soil section. Small areas of silt loam are included with the type owing to their small extent. These areas consist of a surface soil of a black friable, smooth silt loam, 18 to 20 inches in depth, passing gradually into a light gray, heavy silt loam subsoil, mottled with yellow and rusty brown. These silt loam areas occur along Turkey river, two west of Dover Mill and two in the vicinity of Elgin.

In topography the Bremer loam is level to flat and drainage is poor. The small silt loam areas which are included with the type are also flat and poorly drained. The type lies about 10 feet above the normal level of the streams and is not subject to ordinary overflow.

The Bremer loam is practically all used as pasture or for the production of hay. The small area of the silt loam southwest of Elgin is used for general crops. The type is in need of drainage if it is to be cultivated and tiling would prove of large value. It is acid and should be limed. It will need phosphorus in the future if satisfactory crops are to be grown altho it is fairly well supplied at present.

## O'NEILL SANDY LOAM (126)

The O'Neill sandy loam is a minor type in the county, covering only 0.4 percent of the total area. It occurs chiefly along the Turkey river, south of Clermont, near Dover Mill and north of Eldorado. Small areas also occur along Little Turkey river, Volga river and Little Wapsipinicon river.

The surface soil of the O'Neill sandy loam is a dark brown to black sandy loam, 18 to 24 inches in depth. The subsoil is a sticky, sandy clay, at 30 inches resting on sand and gravel. In some areas the gravel may occur within 10 to 12 inches of the surface. Small areas of fine sandy loam too small to separate out are included with this type. They consist of a dark-brown fine sandy loam underlaid at 18 to 20 inches by a brownish-gray, open, loose, fine sandy loam. These areas occur along Little Turkey river and Little Wapsipinicon river.

The O'Neill sandy loam occurs on low and high terraces. In the former location the topography is flat and the type may be flooded during high floods. On the high terraces, the type has been eroded somewhat. This condition occurs on low and high terraces. In the former location the topography is flat and the type may be flooded during high floods. On the high terraces, the type has been eroded somewhat. This condition occurs in the areas north of Eldorado and southeast of Clermont. The high terraces are more droughty. The entire type, however, is excessively drained.

Practically all of the type is under cultivation, corn and oats being the chief crops grown. Corn yields 35 to 50 bushels per acre and oats 30 to 45 bushels in ordinary seasons. Yields are low in dry seasons.



Fig. 10. Waukesha and O'Neill terraces.

The O'Neill sandy loam is in need of organic matter and should receive large applications of farm manure or leguminous green manures should be employed. It is acid and should be limed and it will undoubtedly respond to phosphorus fertilizers.

#### PLAINFIELD SANDY LOAM (98)

The Plainfield sandy loam is small in area covering 0.3 percent of the total area of the county. It occurs chiefly along Otter creek in the vicinity of Oelwein. Smaller areas occur along the streams in other parts of the county.

The surface soil of the Plainfield sandy loam is a grayish-brown sandy loam, containing much coarse sand and medium sand, and about 8 inches in depth. The subsoil is a yellowish-brown sandy loam, with a slightly reddish cast, grading at 18 to 30 inches into a bed of grayish-yellow sand or gravel. In topography the type is level. Drainage is excessive and crops suffer in dry seasons.

Practically all of the type is cultivated. Near Oelwein truck crops, watermelons and potatoes are grown and do well in good seasons. Corn and oats are grown and give fair yields in wet years.

The type is particularly in need of organic matter and should receive liberal applications of farm manure or leguminous green manures. It is acid and needs lime. It would also probably respond to phosphorus fertilizers and when truck crops are grown certain complete commercial fertilizers should undoubtedly be employed.

#### JACKSON SILT LOAM (81)

The Jackson silt loam is minor in area in the county, covering 0.2 percent of the total. It occurs in small areas along the Turkey and Volga rivers. The largest areas are west of Elgin and southeast of Dover Mill.

The surface soil of the Jackson silt loam is a brownish-gray, smooth silt loam

8 to 10 inches in depth, grading into a yellowish-brown open friable silt loam subsoil, containing light gray mottlings in the lower part. Along the uplands the type is modified by the wash and is more or less made up of colluvial material. In topography the type is level and drainage is quite adequate. It lies 10 to 20 feet above overflow.

Practically all of the Jackson silt loam is cultivated, general farm crops being grown. Corn yields 35 to 40 bushels per acre and oats 30 to 40 bushels. Hay crops do well. The type is low in organic matter and crop yields may be much increased by liberal applications of farm manure and the use of legumes as green manures. It is acid and should be limed if good legume growth is to be secured. It is low in phosphorus and phosphorus fertilizers would probably be of value.

#### WAUKESHA SILT LOAM (75)

The Waukesha silt loam is small in area covering 0.2 percent of the total area of the county. It occurs on the terraces along the Turkey and Volga rivers. The largest area is found north of Eldora and many small areas occur along the rivers mentioned or along their tributaries.

The surface soil of the Waukesha silt loam is a dark brown to black smooth friable silt loam extending to a depth of 18 inches. The subsoil is a brown heavy silt loam grading into a brownish-yellow open friable silt loam, becoming yellowish in color in the lower depths. The type is level in topography but it is well drained. It lies 10 to 20 feet above overflow.

The Waukesha silt loam is practically all under cultivation, general farm crops being grown. Corn yields 40 to 50 bushels per acre, oats 40 to 45 bushels and barley 30 bushels.

The Waukesha silt loam will be more productive if liberal applications of farm manure are made. It is acid and needs lime if satisfactory legume growth is to be secured. Phosphorus fertilizers will be needed in the future and would probably give profitable effects in many cases at the present time.

### SWAMP AND BOTTOMLAND SOILS

There are four bottomland soils in the county, classified in the Wabash and Cass series and an area of muck, making five areas of swamp and bottomland. Together they cover 4.3 percent of the total area of the county.

#### WABASH SILT LOAM (26)

The Wabash silt loam is the largest bottomland soil in the county, covering 1.3 percent of the total area. It occurs in numerous small narrow areas, chiefly bordering the smaller streams in the northeastern part of the county. It occurs also along Gundlach creek in the southern part of the county. It is developed most extensively along the creeks tributary to Turkey river and flowing into it from the north.

The surface soil of the type is a black, heavy, smooth silt loam extending to a depth of 24 inches. The typical subsoil is a dark brown silty clay loam. Frequently, however, the subsoil may be very little different in texture and color than the surface soil.



In topography the Wabash silt loam is flat and drainage is naturally poor. Straightening the channels of the streams has improved the drainage in many cases. The type is subject to overflow.

Originally the type was forested with cottonwood, elm, black walnut and ash. Most of it has been cleared and is now used for pasture. About 20 percent is cultivated, corn being the chief crop grown. Yields of 50 to 60 bushels per acre are secured in favorable seasons. Oats are grown to some extent but are apt to lodge. This type needs protection from overflow and thoro drainage if crop yields are to be most satisfactory. It needs lime for the best growth of legumes and would probably respond to phosphorus fertilizers altho the phosphorus content is not so low as in many of the upland types.

#### WABASH LOAM (49)

The Wabash loam is smaller in area than the silt loam, covering 1.1 percent of the total area of the county. It occurs in numerous narrow areas along the streams, being found chiefly along the streams flowing thru the drift region. Some areas occur also in the loessial area, however.

The surface soil of the Wabash loam is a black friable loam 18 to 20 inches deep, containing considerable sand, fine sand and silt. The subsoil is a jet black silty clay loam or clay loam friable and open in structure. Some pockets and thin layers of gray sand occur in the subsoil. Small areas of Cass loam are included with this type as they are too small to separate on the map.

In topography the Wabash loam is flat but drainage is fair, owing to the open structure of the soil and subsoil. It is subject to overflow.

Most of the type is utilized for pasture but some of the larger areas are cultivated. Corn and oats are the chief crops grown. Corn yields 40 to 60 bushels per acre in favorable seasons and oats 30 to 40 bushels.

Some of the areas of the Wabash loam need to be drained if they are to be cultivated and all need protection from overflow if crop growth is to be most satisfactory. The type is acid and needs lime for legume growth. It will probably respond to phosphorus fertilizers in some cases now and these materials will certainly be needed in the future. Small applications of manure would prove of value but heavy applications should not be made, particularly preceding the small grain crop.

#### CASS FINE SANDY LOAM (130)

The Cass fine sandy loam is a minor type in the county, covering 0.9 percent of the total area. It occurs as first bottoms along the Little Wapsipinicon river, the Little Turkey river, Volga creek, Crane creek and Otter creek. The most extensive areas are along the Little Wapsipinicon river in the southwestern part, and along Crane creek and Little Turkey river in the northwestern corner of the county.

The surface soil of the Cass fine sandy loam is a black fine sandy loam extending to a depth of 20 to 24 inches. At that point it passes into a brownish-gray fine sandy loam subsoil. Both soil and subsoil have a loose, open structure.

In topography the type is flat, and is subject to overflow. Only a very small part of the type is under cultivation, most of it being utilized for pasture. Corn is the chief crop grown on the cultivated areas. The type needs protection from overflow if it is to be most productive. It should receive small amounts of farm manure. It may sometimes need lime and phosphorus fertilizers might prove of value.

#### CASS SANDY LOAM (19)

The Cass sandy loam is a minor type, covering 0.9 percent of the total area of the county. It is developed chiefly along the Little Turkey, Turkey, and Volga rivers. It occurs mostly in narrow strips but occasionally widens out to one-half mile or more. The largest areas occur east of Eldorado, in the vicinity of Elgin and southeast of Lima.

The surface soil of this type is a black sandy loam extending to a depth of 15 to 20 inches. The subsoil is a yellowish-brown or grayish-brown loamy sand or sandy loam. In topography the type is nearly flat and drainage is poor. The soil is subject to overflow.

Originally the Cass sandy loam was forested with oak, ash, willow, elm, black walnut and cottonwood. About 60 percent is now used for general farm crops. Corn yields 40 to 60 bushels per acre and oats about 40 bushels in favorable seasons. Barley and rye do well. The soil is well suited also for early vegetables, tomatoes and potatoes.

This type should be protected from overflow to insure good crops. It will respond to small amounts of farm manure. It may need lime in some cases and phosphorus fertilizers might prove of value.

#### MUCK (21a)

There is a small area of muck in the county, amounting to 0.1 percent of the total area. It occurs in small areas in the drift regions in association with the Clyde silty clay loam, the largest area being found 3 miles northwest of Hawk-eye.

Muck consists of black, partially decomposed plant remains, derived from peat which has formed in ponds or in low poorly drained areas. It is about 36 inches in depth as it occurs in Fayette county. Small areas of peat are included with the muck as mapped. Muck is poorly drained and none of it has been reclaimed. It is used solely for pasture. It needs chiefly drainage and may then be made to produce crops. Vegetables do well on it but corn and small grains will not prove very satisfactory for several years after the areas have been drained. It may be seeded to timothy and alsike and utilized for pasture and it will then be brought more quickly into condition for good growth of general farm crops.

#### RESIDUAL SOIL

There is one residual soil in the county, known as the Sogn clay loam. It is small in extent, covering 0.4 per cent of the total area of the county.

## SOGN CLAY LOAM (164)

The Sogn clay loam occurs almost entirely in one area north of Elgin in Pleasant Valley township.

The surface soil of the type is a black plastic clay loam, 15 to 18 inches in depth. This grades into a rusty brown plastic silty clay subsoil mottled with gray and yellow which below 24 inches becomes hard and filled with bluish-green mottlings. Thin layers of white sand sometimes occur in the second foot of the soil section. Lime occurs in the subsoil. No boulders occur.

In topography the Sogn clay loam is flat and drainage is somewhat deficient. The type occurs on three levels, the first 150 to 200 feet above the flood plain, the second, 20 feet higher and the third 40 feet above the second.

The type is used for general farm crops. Corn yields 30 to 50 bushels per acre, oats 20 to 40 bushels and clover and timothy do well. Yields of all crops are low in wet seasons on poorly drained areas. Tiling is the first treatment needed to make this soil more productive. It will respond to farm manure and phosphorus fertilizers might prove of value. It is very necessary that the type be properly cultivated as it will clod if plowed when too wet and bake when too dry. Drainage and manuring will improve its physical conditions and make it easier to handle.

## APPENDIX

### THE SOIL SURVEY OF IOWA

What soils need to make them highly productive and to keep them so, and how their needs may be supplied, are problems which are met constantly on the farm today.

To enable every farmer to solve these problems for his local conditions, a complete survey and study of the soils of the state has been undertaken, the results of which will be published in a series of county reports. This work includes a detailed survey of the soils of each county, following which all the soil types, streams, roads, railroads, etc., are accurately located on a soil map. This portion of the work is being carried on in co-operation with the Bureau of Soils of the United States Department of Agriculture.

Samples of soils are taken and examined mechanically and chemically to determine their character and composition and to learn their needs. Pot experiments with these samples are conducted in the greenhouse to ascertain the value of the use of manure, fertilizers, lime and other materials on the various soils. These pot tests are followed in many cases by field experiments to check the results secured in the greenhouse. The meagerness of the funds available for such work has limited the extent of these field studies and tests have not been possible in each county surveyed. Fairly complete results have been secured, however, on the main types in the large soil areas.

Following the survey, systems of soil management which should be adopted in the various counties and on the different soils are worked out, old methods of treatment are emphasized as necessary or their discontinuance advised, and new methods of proven value are suggested. The published reports as a whole will outline the methods which the farmers of the state must employ if they wish to maintain the fertility of their soils and to insure the best crop production.

The various counties of the state will be surveyed as rapidly as funds will permit, the number included each year being determined entirely by the size of the appropriation available for the work. The order in which individual counties will be chosen depends very largely upon the interest and demand in the county for the work. Petitions signed by the residents, and especially by the farmers or farmers' organizations of the county should be submitted to indicate the sentiment favorable to the undertaking. Such petitions are filed in the order of their receipt and aid materially in the annual selection of counties.

The reports giving complete results of the surveys and soil studies in the various counties will be published in a special series of bulletins as rapidly as the work is completed. Some general information regarding the principles of permanent soil fertility and the character, needs and treatment of Iowa soils, gathered from various published and unpublished data accumulated in less specific experimental work will be included in or appended to all the reports.

#### *PLANT FOOD IN SOILS*

Fifteen different chemical elements are essential for plant food, but many of these occur so extensively in soils and are used in such small quantities that there is practically no danger of their ever running out. Such, for example, is the case with iron and aluminum, past experience showing that the amount of these elements in the soil remains practically constant.

Furthermore, there can never be a shortage in the elements which come primarily from the air, such as carbon and oxygen, for the supply of these in the atmosphere is practically inexhaustible. The same is true of nitrogen, which is now known to be taken directly from the atmosphere by well-inoculated legumes and by certain microscopic organisms. Hence, altho many crops are unable to secure nitrogen from the air and are forced to draw on the soil supply, it is possible by the proper and frequent growing of well-inoculated legumes and their use as green manures, to store up sufficient of this element to supply all the needs of succeeding non-legumes.

Knowledge of the nitrogen content of soils is important in showing whether sufficient green manure or barnyard manure has been applied to the soil. Commercial nitrogenous fertilizers are now known to be unnecessary where the soil is not abnormal, and green

manures may be used in practically all cases. Where a crop must be "forced", as in market gardening, some nitrogenous fertilizers may be of value.

#### THE "SOIL DERIVED" ELEMENTS

Phosphorus, potassium, calcium and sulfur, known as "soil derived" elements, may frequently be lacking in soils, and then a fertilizing material carrying the necessary element must be used. Phosphorus is the element most likely to be deficient in all soils. This is especially true of Iowa soils. Potassium frequently is lacking in peats and swampy soils, but normal soils in Iowa and elsewhere are usually well supplied with this element. Calcium may be low in soils which have borne a heavy growth of a legume, especially alfalfa; but a shortage of this element is very unlikely. It seems possible from recent tests that sulfur may be lacking in many soils, for applications of sulfur fertilizers have proved of value in some cases. However, little is known as yet regarding the relation of this element to soil fertility. If later studies show its importance for plant growth and its deficiency in soils, sulfur fertilizers may come to be considered of much value.

If the amounts of any of these soil-derived elements in soils are very low, they need to be supplied thru fertilizers. If considerable amounts are present, fertilizers containing them are unnecessary. In such cases if the mechanical and humus conditions in the soil are at the best, crops will be able to secure sufficient food from the store in the soil. For example, if potassium is abundant, there is no need of applying a potassium fertilizer; if phosphorus is deficient, a phosphate should be applied. If calcium is low in the soil, it is evident that the soil is acid and lime should be applied, not only to remedy the scarcity of calcium, but also to remedy the injurious acid conditions.

#### AVAILABLE AND UNAVAILABLE PLANT FOOD

Frequently a soil analysis shows the presence of such abundance of the essential plant foods that the conclusion might be drawn that crops should be properly supplied for an indefinite period. However, applications of a fertilizer containing one of the elements present in such large quantities in the soil may bring about an appreciable and even profitable increase in crops.

The explanation of this peculiar state of affairs lies in the fact that all the plant food shown by analysis to be present in soils is not in a usable form; it is said to be *unavailable*. Plants cannot take up food unless it is in solution; hence *available* plant food is that which is in solution. Analyses show not only this soluble or available portion, but also the very much larger insoluble or unavailable part. The total amount of plant food in the soil may, therefore, be abundant for numerous crops, but if it is not made available enough, plants will suffer for proper food.

Bacteria and molds are the agents which bring about the change of insoluble, unavailable material into available form. If conditions in the soil are satisfactory for their vigorous growth and sufficient total plant food is present, these organisms will bring about the production of enough soluble material to support good crop growth. The soil conditions necessary for the best growth and action of bacteria and molds are the same as those which are required by plants. The methods necessary to maintain permanent soil fertility will, therefore, insure satisfactory action of these organisms and the sufficient production of available plant food. The nitrogen left in the soil in plant and animal remains is entirely useless to plants and must be changed to be available. Bacteria bring about this change and they are all active in normal soils which are being properly handled.

Phosphorus is found in soil mainly in the mineral known as apatite and in other insoluble substances. Potassium occurs chiefly in the insoluble feldspars. Therefore, both of these elements, as they normally occur in soils, are unavailable. However, the growth of bacteria and molds in the soil brings about a production of carbon dioxide and organic acids which act on the insoluble phosphates and potassium compounds and make them available for plant food.

Calcium occurs in the soil mainly in an unavailable form, but the compounds containing it are attacked by the soil water carrying the carbon dioxide produced by bacteria and molds and as a result a soluble compound is formed. The losses of lime from soils are largely the result of the leaching of this soluble compound.

Sulfur, like nitrogen, is present in the soils chiefly in plant and animal remains, in which form it is useless to plants. As these materials decompose, however, so-called sulfur bacteria appear and bring about the formation of soluble and available sulfates.

The importance of bacterial action in making the store of plant food in the soil available is apparent. With proper physical and chemical soil conditions, all the necessary groups of bacteria mentioned become active and a vigorous production of soluble nitro-

TABLE I. PLANT FOOD IN CROPS AND VALUE

Calculating Nitrogen (N) at 16c (Sodium Nitrate ( $\text{NaNO}_3$ )), Phosphorus (P) at 12c (Acid Phosphate), and Potassium (K) at 6c (Potassium Chloride ( $\text{KCl}$ ))

Crop	Yield	Plant Food, Lbs.			Value of Plant Food			Total Value of Plant Food
		Nitrogen	Phosphorus	Potass'm	Nit'g'n	Phosphorus	Potass'm	
Corn, grain	75 bu.	75	12.75	14	\$12.00	\$1.52	\$0.84	\$14.37
Corn, stover	2.25 T.	36	4.5	39	5.76	0.54	2.34	8.64
Corn, crop	.....	111	17.25	53	17.76	2.07	3.18	23.01
Wheat, grain	30 bu.	42.6	7.2	7.8	6.81	0.86	0.46	8.13
Wheat, straw	1.5 T.	15	2.4	27	2.40	0.28	1.62	4.30
Wheat, crop	.....	57.6	9.6	34.8	9.21	1.14	2.08	12.43
Oats, grain	50 bu.	33	5.5	8	5.28	0.66	0.48	6.42
Barley, straw	1.25 T.	15.5	2.5	26	2.48	0.30	1.56	8.28
Oats, crop	.....	48.5	8	34	7.76	0.96	2.04	14.70
Barley, grain	30 bu.	23	5	5.5	3.68	0.60	0.33	4.61
Barley, straw	0.75 T.	9.5	1	13	1.52	0.12	0.78	2.42
Barley, crop	.....	32.5	6	18.5	5.20	0.72	1.11	7.03
Rye, grain	30 bu.	29.4	6	7.8	4.70	0.72	0.46	5.88
Rye, straw	1.5 T.	12	3	21	1.92	0.36	1.26	3.54
Rye, crop	.....	41.4	9	28.8	6.62	1.08	1.72	9.42
Potatoes	300 bu.	63	12.7	90	10.08	1.25	5.40	17.00
Alfalfa, hay	6 T.	300	27	144	48.00	3.24	8.64	59.88
Timothy, hay	3 T.	72	9	67.5	11.52	1.08	3.95	16.55
Clover, hay	3 T.	120	15	90	19.20	1.80	5.40	16.40

gen, phosphorus, potassium, calcium and sulfur results. If crops are to be properly nourished, care should always be taken that the soil is in the best condition for the growth of bacteria.

#### REMOVAL OF PLANT FOOD BY CROPS

The decrease of plant food in the soil is the direct result of removal by crops, altho there is often some loss by leaching also. A study of the amounts of nitrogen, phosphorus, and potassium removed by some of the common farm crops will show how rapidly these elements are used up under average farming conditions.

The amounts of these elements in various farm crops are given in table I. The amount of calcium and sulfur in the crops is not included, as it is only recently that the removal of these elements has been considered important enough to warrant analyses.

The figures in the table show also the value of the three elements contained in the different crops, calculated from the market value of fertilizers containing them. Thus the value of nitrogen is figured at 16 cents per pound, the cost of the elements in nitrate of soda; phosphorus at 12 cents, the cost in acid phosphate, and potassium at 6 cents, the cost in muriate of potash.

It is evident from the table that the continuous growth of any common farm crop without returning these three important elements will lead finally to a shortage of plant food in the soil. The nitrogen supply is drawn on the most heavily by all the crops, but in the case of alfalfa and clover only a small part should be taken from the soil. If these legumes are inoculated as they should be, they will take most of their nitrogen from the atmosphere. The figures are therefore entirely too high for the nitrogen taken from the soil by these two crops, but the loss of nitrogen from the soil by removal in non-leguminous crops is considerable. The phosphorus and potassium in the soil are also rapidly reduced by the growth of ordinary crops. While the nitrogen supply may be kept up by the use of leguminous green manure crops, phosphorus and potassium must be supplied by the use of expensive commercial fertilizers.

The cash value of the plant food removed from soils by the growth and sale of various crops is considerable. Even where the grain alone is sold and the crop residues are returned to the soil, there is a large loss of fertility, and if the entire crop is removed and no return made, the loss is almost doubled. It is evident, therefore, that in calculating the actual income from the sale of farm crops, the value of the plant food removed from the soil should be subtracted from the proceeds, at least in the case of constituents which must be replaced at the present time.

Of course, if the crops procured are fed on the farm and the manure carefully preserved and used, a large part of the valuable matter in the crops will be returned to the soil. This is the case in livestock and dairy farming where the products sold con-

tain only a portion of the valuable elements of plant food removed from the soil. In grain farming, however, green manure crops and commercial fertilizers must be depended upon to supply plant food deficiencies in the soil. It should be mentioned that the proper use of crop residues in this latter system of farming reduces considerably plant food loss.

#### REMOVAL FROM IOWA SOILS

It has been conservatively estimated that the plant food taken from Iowa soils and shipped out of the state in grain amounts to about \$30,000,000 annually. This calculation is based on the estimate of the secretary of the Western Grain Dealers' Association that 20 percent of the corn and 35 to 40 percent of the oats produced in the state is shipped off the farms.

This loss of fertility is unevenly distributed over the state, varying as farmers do more or less livestock and dairy farming or grain farming. In grain farming, where no manure is produced and the entire grain crop is sold, the soil may very quickly become deficient in certain necessary plant foods. Eventually, however, all soils are depleted in essential food materials, whatever system of farming is followed.

This loss of fertility is great enough to demand serious attention. Careful consideration should certainly be given to all means of maintaining the soils of the state in a permanently fertile condition.

#### PERMANENT FERTILITY IN IOWA SOILS

The preliminary study of Iowa soils, already reported, revealed the fact that there is not an inexhaustible supply of nitrogen, phosphorus and potassium in the soils of the state. Potassium was found in much larger amounts than the other two elements, and it was concluded, therefore, that attention should be centered at the present time on nitrogen and phosphorus. In spite of the fact that Iowa soils are still comparatively fertile and crops are still large there is abundant evidence at hand to prove that the best possible yields of certain crops are not being obtained in many cases because of the lack of necessary plant foods or because of the lack of proper conditions in the soil for the growth of plants and the production, by bacteria, of available plant food.

Proper systems of farming will insure the production of satisfactory crops and the maintenance of permanent fertility and the adoption of such systems should not be delayed until the crop yields are much lower, for then it will involve a long, tedious and very expensive fight to bring the soil back to a fertile condition. If proper methods are put into operation while comparatively large amounts of certain plant foods are still present in the soil, it is relatively easy to keep them abundant and attention may be centered on other elements likely to be limiting factors in crop production.

Soils may be kept permanently fertile by adopting certain practices which will be summarized here.

#### CULTIVATION AND DRAINAGE

Cultivation and drainage are two of the most important farm operations in keeping the soil in a favorable condition for soil production, largely because they help control the moisture in the soil.

The moisture in soils is one of the most important factors governing crop production. If the soil is too dry, plants suffer for lack of water necessary to bring them their food and also for lack of available plant food. Bacterial activities are so restricted in dry soils that the production of available plant food practically ceases. If too much moisture is present, plants likewise refuse to grow properly because of the exclusion of air from the soil and the absence of available food. Decay is checked in the absence of air, all beneficial bacterial action is limited and humus, or organic matter, containing plant food constituents in an unavailable form, accumulates. The infertility of low-lying, swampy soils is a good illustration of the action of excessive moisture in restricting plant growth by stopping aeration and limiting beneficial decay processes.

While the amount of moisture in the soil depends very largely on the rainfall, any excess of water may be removed from the soil by drainage and the amount of water present in the soil may be conserved during the periods of drouth by thorough cultivation or the maintaining of a good mulch. The need for drainage is determined partly by the nature of the soil, but more particularly by the subsoil. If the subsoil is a heavy, tight clay, a surface clay loam will be rather readily affected by excessive rainfall. On the other hand, if the surface soil is sandy, a heavy subsoil will be of advantage in preventing the rapid drying out of the soil and also in checking losses of valuable matter by leaching.

Many acres of land in the Wisconsin drift area in Iowa have been reclaimed and made fertile thru proper drainage, and one of the most important farming operations is the laying of drains to insure the removal of excessive moisture in heavy soils.

The loss of moisture by evaporation from soils during periods of heavy drouth may be checked to a considerable extent if the soil is cultivated and a good mulch is main-

tained. Many pounds of valuable water are thus held in the soil and a satisfactory crop growth secured when otherwise a failure would occur. Other methods of soil treatment, such as liming, green manuring and the application of farm manures, are also important in increasing the water-holding power of light soils.

#### THE ROTATION OF CROPS

Experience has shown many times that the continuous growth of one crop takes the fertility out of a soil much more rapidly than a rotation of crops. One of the most important farm practices, therefore, from the standpoint of soil fertility, is the rotation of crops on a basis suited to the soil, climatic, farm and market conditions. The choice of crops is so large that no difficulty should be experienced in selecting those suitable for all conditions.

Probably the chief reason why the rotation of crops is beneficial may be found in the fact that different crops require different amounts of the various plant foods in the soil. One particular crop will remove a large amount of one element and the next crop if it be the same kind, will suffer for a lack of that element. If some other crop, which does not draw as heavily on that particular plant food, is rotated with the former crop, a balance in available plant food is reached.

Where a cultivated crop is grown continuously, there is a much greater loss of organic matter or humus in the soil than under a rotation. This fact suggests a second explanation for the beneficial effects of crop rotation. With cultivation, bacterial action is much increased and the humus in the soil may be decomposed too rapidly and the soil injured by the removal of the valuable material. Then the production of available plant food in the soil will be hindered or stopped and crops may suffer. The use of legumes in rotations is of particular value since when they are well inoculated and turned under, they not only supply organic matter to the soil, but they also increase the nitrogen content.

There is a third explanation of the value of rotations. It is claimed that crops in their growth produce certain substances called "toxic" which are injurious to the same crop, but have no effect on certain other crops. In a proper rotation the time between two different crops of the same plant is long enough to allow the "toxic" substance to be disposed of in the soil or made harmless. This theory has not been commonly accepted, chiefly because of the lack of confirmatory evidence. It seems extremely doubtful if the amounts of these "toxic" substances could be large enough to bring about the effects evidenced in continuous cropping.

But, whatever the reason for the bad effects of continuous cropping, it is evident that for all good systems of farming some definite rotation should be adopted, and that rotations should always contain a legume, because of the value of such crops to the soil. In no other way can the humus and nitrogen content of soils be kept up so cheaply and satisfactorily as by the use of legumes, either as regular or "catch" crops in the rotation.

#### MANURING

There must always be enough humus, or organic matter, and nitrogen in the soil if satisfactory crops are to be secured. Humus not only keeps the soil in the best physical condition for crop growth, but it supplies a considerable portion of nitrogen. An abundance of humus may always be considered a reliable indication of the presence of much nitrogen. This nitrogen does not occur in a form available for plants, but with proper physical conditions in the soil, the nonusable nitrogen in the animal and vegetable matter which makes up the humus, is made usable by numerous bacteria and changed into soluble and available nitrates.

The humus, or organic matter, also encourages the activities of many other bacteria which produce carbon dioxide and various acids which dissolve and make available the insoluble phosphorus and potassium in the soil.

Three materials may be used to supply the organic matter and nitrogen of soils. These are farm manure, crop residues and green manure, the first two being much more common.

Farm manure is composed of the solid and liquid excreta of animals, litter, unconsumed food and other waste materials, and supplies an abundance of organic matter, much nitrogen and millions of valuable bacteria. It contains, in short, a portion of the plant food present in the crops originally removed from the soil and in addition the bacteria necessary to prepare this food for plant use. If it were possible to apply enough amounts of farm manure, no other material would be necessary to keep the soil in the best physical condition, insure efficient bacterial action and keep up the plant food supply. But manure cannot serve the soil thus efficiently, for even under the very best methods of treatment and storage, 15 per cent of its valuable constituents, mainly nitrogen, are lost. Furthermore, only in a very few instances is enough produced on a farm to supply its needs. On practically all soils, therefore, some other material must be applied with the manure to maintain fertility.



Crop residues, consisting of straw, stover, roots and stubble, are important in keeping up the humus, or organic matter content of soils. Table I shows that a considerable portion of the plant food removed by crops is contained in the straw and stover. On all farms, therefore, and especially on grain farms, the crop residues should be returned to the soil to reduce the losses of plant food and also to aid in maintaining the humus content. These materials alone are, of course, insufficient and farm manure must be used when possible, and green manures also.

Green manuring should be followed to supplement the use of farm manures and crop residues. In grain farming, where little or no manure is produced, the turning under of leguminous crops for green manures must be relied upon as the best means of adding humus and nitrogen to the soil, but in all other systems of farming also it has an important place. A large number of legumes will serve as green manure crops and it is possible to introduce some such crop into almost any rotation without interfering with the regular crop. It is this peculiarity of legumes, together with their ability to use the nitrogen of the atmosphere when well inoculated and thus increase the nitrogen content of the soil which gives them their great value as green manure crops.

It is essential that the legumes used be well inoculated. Their ability to use the atmospheric nitrogen depends on that. Inoculation may be accomplished by the use of soil from a field where the legume has previously been successfully grown and well inoculated or by the use of inoculating materials that may be purchased. If the legume has never been grown on the soil before, or has been grown without inoculation, then inoculation should be practiced by one of these methods.

By using all the crop residues, all the manure produced on the farm, and giving well-inoculated legumes a place in the rotation for green manure crops, no artificial means of maintaining the humus and nitrogen content of soils need be resorted to.

#### THE USE OF PHOSPHORUS

Iowa soils are not abundantly supplied with phosphorus. Moreover, it is possible by the use of manures, green manures, crop residues, straw, stover, etc., to return to the soil the entire amount of that element removed by crops. Crop residues, stover and straw merely return a portion of the phosphorus removed, and while their use is important in checking the loss of the element, they cannot stop it. Green manuring adds no phosphorus that was not used in the growth of the green manure crop. Farm manure returns part of the phosphorus removed by crops which are fed on the farm, but not all of it. While, therefore, immediate scarcity of phosphorus in Iowa soils cannot be positively shown, analyses and results of experiments show that in the more or less distant future, phosphorus must be applied or crops will suffer for a lack of this element. Furthermore, there are indications that its use at present would prove profitable in some instances.

Phosphorus may be applied to soils in three commercial forms, bone meal, acid phosphate and rock phosphate. Bone meal cannot be used generally, because of its extremely limited production, so the choice rests between rock phosphate and acid phosphate. Experiments are now under way to show which is more economical for farmers in the state. Many tests must be conducted on a large variety of soil types, under widely differing conditions, and thru a rather long period of years. It is at present impossible to make these experiments as complete as desirable, owing to small appropriations for such work, but the results secured from the tests now in progress will be published from time to time in the different county reports.

Until such definite advice can be given for individual soil types, it is urged that farmers who are interested make comparisons of rock phosphate and acid phosphate on their own farms. In this way they can determine at first hand the relative value of the two materials. Information and suggestions regarding the carrying out of such tests may be secured upon application to the Soils Section.

#### LIMING

Practically all crops grow better on a soil which contains lime, or in other words, on one which is not acid. As soils become acid, crops grow smaller, bacterial activities are reduced and the soil becomes infertile. Crops are differently affected by acidity in the soil; some refuse to grow at all; others grow but poorly. Only in a very few instances can a satisfactory crop be secured in the absence of lime. Therefore, the addition of lime to soils in which it is lacking is an important principle in permanent soil fertility. All soils gradually become acid because of the losses of lime and other basic materials thru leaching and the production of acids in the decomposition processes constantly occurring in soils. Iowa soils are no exceptions to the general rule, as was shown by the tests of many representative soils reported in Bulletin No. 151 of this station. Particularly are the soils in the Iowan drift, Mississippi loess and Southern Iowa loess areas likely to be acid.

All Iowa soils should therefore be tested for acidity before the crop is seeded, particu-

larly when legumes, such as alfalfa or red clover, are to be grown. Any farmer may test his own soil and determine its need of lime, according to simple directions in bulletin No. 151, referred to above.

As to the amount of lime needed for acid soils as a general rule sufficient should be applied to neutralize the acidity in the surface soil and then an additional amount of one or two tons per acre.

### SOIL AREAS IN IOWA

There are five large soil divisions in Iowa, the Wisconsin drift, the Iowan drift, the Missouri loess, the Mississippi loess and the Southern Iowa loess. These five divisions of the soils of the state are based on the geological forces which brought about the formation of the various soil areas. The various areas are shown in the map, fig. 12.

With the exception of the northeastern part of the state, the whole surface of Iowa was in ages past overrun by great continental ice sheets. These great masses of ice moved slowly over the land, crushing and grinding the rocks beneath and carrying along with them the material which they accumulated in their progress. Five ice sheets invaded Iowa at different geological eras, coming from different directions and carrying, therefore, different rock material with them.

The deposit, or sheet, of earth debris left after the ice of such glaciers melts is called "glacial till" or "drift" and is easily distinguished by the fact that it is usually a rather stiff clay containing pebbles of all sorts as well as large boulders of "nigger heads." Two of these drift areas occur in Iowa today, the Wisconsin drift and the Iowan drift, covering the north central part of the state. The soils of these two drift areas are quite different in chemical composition, due primarily to the different ages of the two ice invasions. The Iowan drift was laid down at a much earlier period and is somewhat poorer in plant food than the Wisconsin drift soil, having undergone considerable leaching in the time which has elapsed since its formation.

The drift deposits in the remainder of the state have been covered by so-called loess soils, vast accumulations of dust-like materials which settled out of the air during a period of geological time when climatic conditions were very different than at present. These loess soils are very porous in spite of their fine texture and they rarely contain large pebbles or stones. They present a strong contrast to the drift soils, which are somewhat heavy in texture and filled with pebbles and stone. The three loess areas in the state, the Missouri, the Mississippi and the Southern Iowa, are distinguished by differences in texture and appearance, and they vary considerably in value for farming purposes. In some sections the loess is very deep, while in other places the underlying leached till or drift soil is very close to the surface. The fertility of these soils and their needs are greatly influenced, therefore, by their depth.

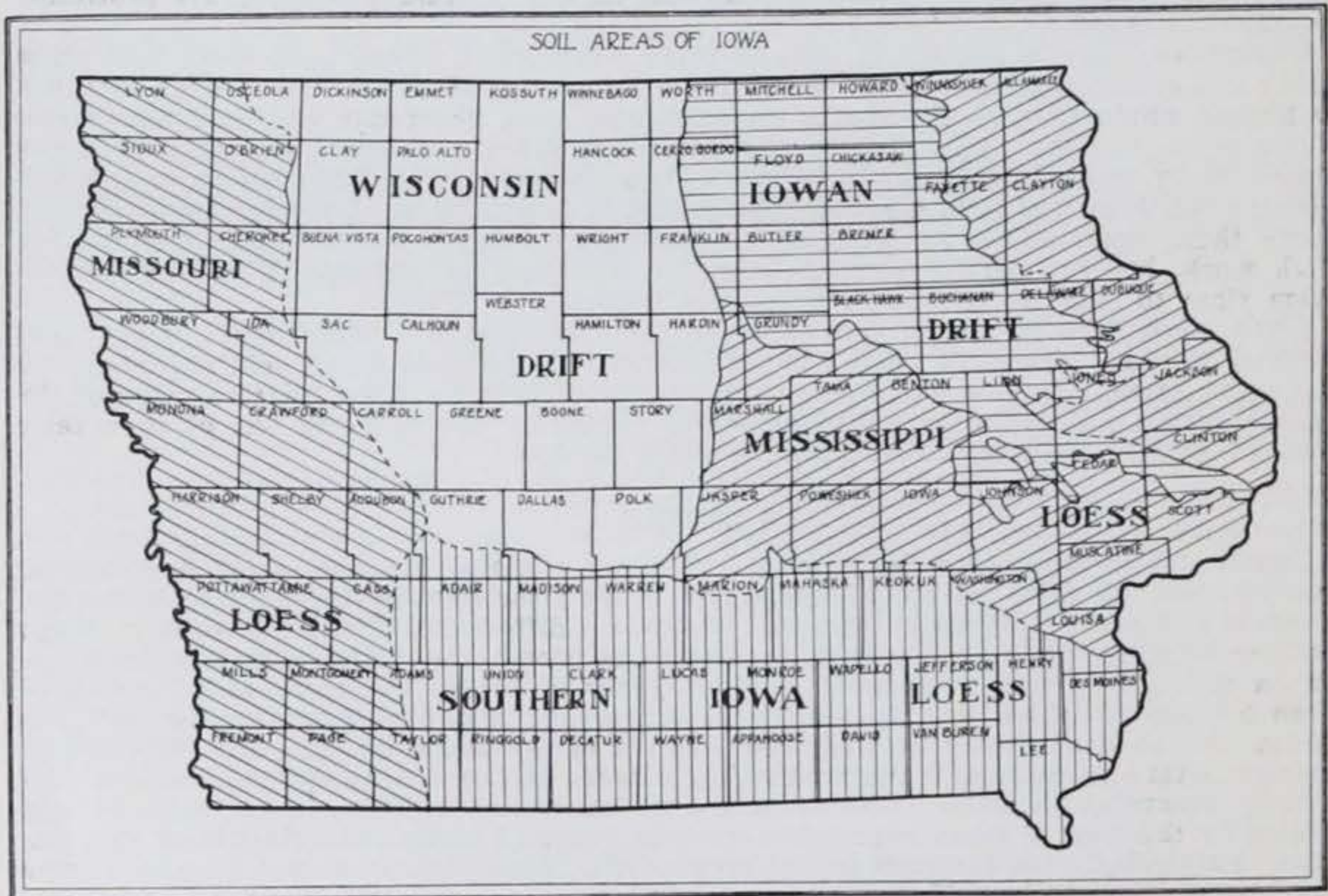


Fig. 11. Map showing the principal soil areas in Iowa.

It will be seen that the soils of the state may be roughly divided into two classes, drift soils and loess soils, and that further divisions may then be made into various drift and loess soils because of differences in period of formation, characteristics and general composition. More accurate information demands, however, that further divisions be made. The different drift and loess soils contain large numbers of soil types which vary among themselves, and each of these should receive special attention.

THE SOIL SURVEY BY COUNTIES

It is apparent that a general survey of the soils of the state can give only a very general idea of soil conditions. Soils vary so widely in character and composition, depending on many other factors than their source, that definite knowledge concerning their needs can be secured only by thoro and complete study of them in place in small areas. Climatic conditions, topography, depth and character of soil, chemical and mechanical composition and all other factors affecting crop production must be considered.

This is what is accomplished by the soil survey of the state by counties, and hence the needs of individual soils and proper systems of management may be worked out in much greater detail and be much more complete than would be possible by merely considering the large areas separated on the basis of their geological origin. In other words, while the unit in the general survey is the geological history of the soil area, in the soil survey by counties or any other small area, the unit is the soil type.

GENERAL SOIL CHARACTERISTIC

Soil types possess more or less definite characteristics which may be determined largely in the field, altho some laboratory study is necessary for final disposition. Usually the line of separation between adjoining soil types is quite distinct and it is a simple matter to locate the type boundaries. In some cases, however, there is a gradation from one type to another and then the boundaries may be fixed only with great difficulty. The error introduced into soil survey work from this source is very small and need cause little concern.

The factors which must be taken into account in establishing soil types have been well enumerated by the Illinois Experiment Station in its Soil Report No. 1.

They are:

1. The geological origin of the soil, whether residual, glacial, loessial, alluvial, coluvial or cumulose.
2. The topography or lay of the land.
3. The structure or depth and character of the surface, subsurface and subsoil.
4. The physical and mechanical composition of different strata composing the soil, as the percentages of gravel, sand, silt, clay and organic matter which they contain.
5. The texture or porosity, granulation, friability, plasticity, etc.
6. The color of the strata.
7. The natural drainage.
8. The agricultural value based upon its natural productiveness.
9. Native vegetation.
10. The ultimate chemical composition and reaction.

The common soil constituents may be given as follows:†

Organic matter	{	All partially destroyed or decomposed vegetable and animal material.
Inorganic matter	{	Stones—over 32 mm.* Gravel—32—20 mm. Very coarse sand—2.0—1.0 mm. Coarse sand—1.0—0.5 mm. Medium sand—0.5—0.25 mm. Fine sand—0.25—0.10 mm. Very fine sand—0.10—0.05 mm. Silt—0.05—0.00 mm.

SOILS GROUPED BY TYPES

The general groups of soils by types are indicated thus by the Bureau of Soils.

*Peats*—Consisting of 35 percent or more of organic matter, sometimes mixed with more or less sand or soil.

*Peaty Loams*—15 to 35 percent organic matter mixed with much sand and silt and a little clay.

*Mucks*—25 to 35 percent of partly decomposed organic matter mixed with much clay and some silt.

*Clays*—Soils with more than 30 per cent clay, usually mixed with much silt; always more than 50 percent silt and clay.

\*25 mm. equals 1 in. †Bureau of Soils Field Book. ‡Loc. cit.

*Silty Clay Loams*—20 to 30 percent clay and more than 50 percent silt.

*Clay Loams*—20 to 30 percent clay and less than 50 percent silt and some sand.

*Silt Loams*—20 percent clay and more than 50 percent silt mixed with some sand.

*Loams*—Less than 20 percent clay and less than 50 percent silt and from 30 to 50 percent sand.

*Sandy Clays*—20 per cent silt and small amounts of clay up to 30 percent.

*Fine Sandy Loams*—More than 50 percent fine sand and very fine sand mixed with less than 25 percent very coarse sand, coarse sand and medium sand, much silt and a little clay; silt and clay 20 to 50 per cent.

*Sandy Loams*—More than 25 percent very coarse, coarse and medium sand; silt and clay 20 to 50 percent.

*Very Fine Sand*—More than 50 percent fine sand and less than 25 percent very coarse, coarse and medium sand, less than 20 percent silt and clay.

*Fine Sand*—More than 50 per cent fine sand and less than 25 percent very coarse, coarse and medium sand, less than 20 percent silt and clay.

*Sand*—More than 25 percent very coarse, coarse and medium sand, less than 50 percent fine sand, less than 20 percent silt and clay.

*Coarse Sand*—More than 25 percent very coarse, coarse and medium sand, less than 50 percent of other grades, less than 20 percent silt and clay.

*Gravelly Loams*—25 to 50 percent very coarse sand and much sand and some silt.

*Gravels*—More than 50 percent very coarse sand.

*Stony Loams*—A large number of stones over one inch in diameter.

#### METHODS USED IN THE SOIL SURVEY

It may be of some interest to state briefly the methods which are followed in the field in surveying the soils.

As has been indicated the completed map is intended to show the accurate location and boundaries, not only of all soil types but also of the streams, roads, railroads, etc.

The first step, therefore, is the choice of an accurate base map and any official map of the county may be chosen for this purpose. Such maps are always checked to correspond correctly with the land survey. The location of every stream, road and railroad on the map is likewise carefully verified and corrections are frequently necessary. When an accurate base map is not available the field party must first prepare one.

The section is the unit area by which each county is surveyed and mapped. The distances in the roads are determined by an odometer attached to the vehicle, and in the field by pacing, which is done with accuracy. The directions of the streams, roads, railroads, etc., are determined by the use of the compass and the plane table. The character of the soil types is ascertained in the section by the use of the auger, an instrument for sampling both the surface soil and the subsoil. The boundaries of each type are then ascertained accurately in the section and indicated on the map. Many samplings are frequently necessary, and individual sections may contain several soil types and require much time for mapping. In other cases, the entire section may contain only one soil type, which fact is readily ascertained, and in that case the mapping may proceed rapidly.

When one section is completed, the party passes to the next section and the location of all soil types, streams, etc., in that section is then checked with their location in the adjoining area just mapped. Careful attention is paid to the topographic features of the area, or the "lay of the land," for the character of the soils is found to correspond very closely to the conditions under which they occur.

The field party is composed of two men, and all observations, measurements and soil type boundaries are compared and checked by each man.

The determinations of soil types are verified also by inspection and by consultation with those in charge of the work at the Bureau of Soils and at the Iowa Agricultural Experiment Station. When the entire county is completed, all the section maps of field sheets are assembled and any variations or questionable boundaries are verified by further observations of the particular area.

The completed map, therefore, shows as accurately as possible all soils and soil boundaries, and it constitutes also an exact road map of the county.

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