SOIL SURVEY OF IOWA

FLOYD COUNTY

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

Agronomy Section

Soils

Soil Survey Report No. 48
June, 1927
Ames, Iowa

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Report No. 48—FLOYD COUNTY SOILS

By W. H. Stevenson and P. E. Brown with the assistance of A. M. O'Neal, L. W. Forman and R. E. Bennett

IOWA AGRICULTURAL
EXPERIMENT STATION
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CONTENTS

Introduction 3
Geology of Floyd County 7
Physiography and drainage 8
Soils of Floyd County 9
Fertility in Floyd County soils 12
Greenhouse experiments 19
Field experiments 26
The needs of Floyd County soils as indicated by laboratory, field and greenhouse tests 36
Liming 37
Manuring 37
Use of commercial fertilizers 39
Rotation of crops 42
Drainage 42
Prevention of erosion 44
Individual soil types in Floyd County 44
Drift soils 44
Loess soils 55
Swamp and bottomland soils 62
Appendix: The soil survey of Iowa 65

FLOYD COUNTY SOILS*

By W. H. Stevenson and P. E. Brown with the assistance of A. M. O'Neal, L. W. Forman and R. E. Bennett

Floyd County is located in northeastern central Iowa in the second tier of counties south of the Minnesota state line and in the fourth tier west of the Mississippi River. It is entirely within the Iowan drift soil area and practically all the soils in the county are glacial in origin.

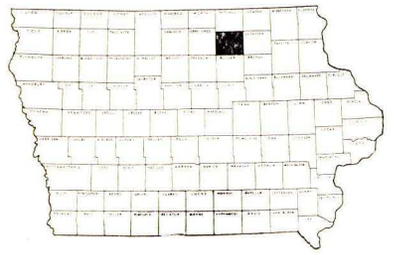

Fig. 1. A map showing the location of Floyd County.

The total area of the county is 495 square miles or 316,800 acres. Of this area 304,208 acres or 96 percent is in farm land. The total number of farms is 1,878 and the average size of the farms is 162 acres. The farms of the county are operated by 785 owners, 288 relative renters, 631 renters, 171 both owning and renting, and 3 unclassified. The following figures taken from the Iowa Yearbook of Agriculture for 1925 show the utilization of the farm land of the county:

Acreage in general farm crops	211,636
Acreage in farm buildings, public highways and feed lots	15,583
Acreage in pasture	73,963
Acreage in waste land not utilized for any purpose	1,214
Acreage in farm wood lots used for timber only	1,005
Acreage of crop land lying idle	117
Acreage in crops not otherwise listed	656

THE AGRICULTURE OF FLOYD COUNTY

The type of agriculture practiced in Floyd County at the present time consists of what may be termed a system of general farming, including the growing of grain and hay for feed and sale, the raising of hogs, the raising and feeding of beef cattle and some dairying. Truck crops and fruit crops are grown only on a small scale to supply the home demand. A large part of the corn and small grain crops produced are fed on the farms and all the hay is thus utilized. The income on the farms comes, therefore, from the sale of surplus corn, small grains, hogs and beef cattle and in a few cases from the sale of dairy products. In many cases the income on individual farms is increased materially thru the sale of special crops or of livestock other than that mentioned.

The acreage in waste land is not large but in many cases much of this land might be reclaimed and made productive thru proper methods of treatment. General recommendation for the reclamation of waste land cannot be given because of the fact that the infertility is due to various factors. In the descriptions of individual soil types given later in this report, special treatments necessary for the reclamation of waste areas will be discussed and recommendations

*See Soil Survey of Floyd County, Iowa, by A. M. O'Neal of the Iowa Agricultural Experiment Station and A. W. Goke of the U. S. Department of Agriculture. Field Operations of the Bureau of Soils 1922.

TABLE I. AVERAGE YIELD AND VALUE OF PRINCIPAL CROPS GROWN IN FLOYD COUNTY, IOWA*

Crop	Acreage	Percent of total farm land of the county	Bushels or tons per acre	Total bushels or tons	Average price	Total value of crop
Corn	100,490	33.1	41.9	4,210,531	$ .56	$2,357,897
Oats	77,316	25.4	38.0	2,919,034	.32	934,090
Winter wheat	24	.01	15.0	320	1.36	435
Spring wheat	146	.04	15.0	2,190	1.30	2,847
Barley	1,967	.6	34.0	66,878	.57	38,120
Rye	318	.01	15.0	4,770	.80	3,816
Tame hay	25,562	8.4	1.3	33,230	13.50	448,605
Wild hay	2,603	.9	1.0	2,603	10.50	27,331
Alfalfa	205	.07	2.4	492	17.50	8,610
Pasture	73,963	24.3	...	.....	....	.....

*Iowa Yearbook of Agriculture, 1925.

given. Advice for the treatment of land in special cases may be secured from the Soils Section of the Iowa Agricultural Experiment Station upon request.

The general farm crops grown in Floyd County in the order of their importance are corn, oats, hay, barley, alfalfa, rye and wheat. The average yields and value of these crops are given in table I.

Corn is by far the most important crop grown from the standpoint both of acreage and of value. In 1925, it was grown on 33.1 percent of the total farm land of the county and average yields of the crop amounted to 41.9 bushels per acre. The white varieties of corn, mainly Silver King, are grown on more than sixty percent of the total area in this crop. The yellow varieties grown include various strains of the hard dent varieties which have been selected to suit the particular region. The major portion of the corn crop produced is fed on the farms to the work stock, beef cattle, hogs and dairy cows. In some sections a part of the corn produced is shipped to outside markets. About 40 to 50 percent of the farms are supplied with silos and much of the crop is used for silage purposes. Some of the corn is hogged down and in such cases soybeans are often drilled in the corn.

The second crop in acreage and value is oats. In 1925, this crop was grown on 25.4 percent of the total area. Average yields in that season amounted to 38 bushels per acre. The common varieties grown include Green Russian and Iowar. Iowa 105 and Iowa 103 have also been used. Considerably more than 50 percent of the oats crop is used on the farms as feed for the work stock, hogs and beef cattle. The remainder is marketed outside thru elevators.

Hay is the third crop in acreage and value. In 1925, 8.4 percent of the total farm land was in tame hay. Average yields of the crop amounted to 1.3 tons per acre. The chief tame hay crop consists of clover and timothy mixed. Some clover is grown alone and some timothy is likewise grown alone. Occasionally these crops are grown for seed. In 1925, there was a rather considerable area in the county on which timothy was grown for seed. There is a small area of wild hay and average yields of this crop amount to one ton per acre. Practically all of the hay crop grown is utilized for feeding purposes on the farms.

Barley is grown rather extensively, with average yields of 34 bushels per acre in 1925. The value of this crop is considerable. It is frequently used in the

rotation in place of the oats. The entire amount of barley grown is fed on the farms.

Alfalfa is grown to only a very limited extent but when it is properly seeded, with the seed inoculated and the soil limed, very satisfactory yields of this crop may be secured. In 1925, an average yield of 2.4 tons per acre was reported. Alfalfa may be a very profitable crop for use in this county.

Other crops of minor importance include rye, buckwheat, flax and sorghum. In the western part of the county there is a rather considerable area which is utilized for the production of Pearl and Japan millet seed. Soybeans are often grown with the corn when this crop is to be used for silage or hogged down.

Fruit is not grown extensively but small orchards are found on practically all farms to supply fruit for the home demand. There is one commercial apple orchard and very excellent results are secured on this orchard. The industry might probably be developed with profit in other parts of the county.

FLOYD COUNTY'S LIVESTOCK INDUSTRY

The extent of the livestock industry in Floyd County is indicated by the following figures taken from the Iowa Monthly Crop Report for July 1, 1926, which is based on the January 1, 1926 estimates of the Bureau of Crops and Livestock Estimates of the U. S. Department of Agriculture:

Horses	9,900
Mules	200
All cattle	41,600
Hogs	79,900
Sheep	6,600

The raising of hogs is one of the most important livestock industries and on most of the farms a large part of the farm income is derived from the sale of hogs. Duroc Jersey and Poland China are the most popular breeds. There are, however, only four or five breeders of purebred animals in the county. The hogs are sold usually in carload lots to Mason City, Waterloo, and Austin, Minn.

The beef cattle industry is developed quite extensively and considerable farm income is derived from this source. Only a few farmers raise cattle, most of them purchasing in the fall on the Omaha and Sioux City markets. Angus and Shorthorn grades are preferred, altho there are a few herds of Hereford cattle.

A few horses are raised on many farms to supply the home demand but the industry is not developed in a commercial way. Sheep are raised and fattened to only a very limited extent. Poultry production is a side-line on most farms and the sale of poultry products adds considerably to the income on some farms. It would undoubtedly be profitable to give more attention to this industry in many cases.

Dairying has been developed to some extent and on most farms there are a few milk cows to supply the home needs. In some parts of the county surplus milk is sold and in many cases the sale of milk and other dairy products may add considerably to the farm income. There is only one creamery in the county but there are three or four located just outside.

THE FERTILITY SITUATION IN FLOYD COUNTY

The soils of Floyd County are naturally quite fertile and in general very satisfactory yields of farm crops are secured. There are many cases, however, where the yields are not as large as they should be, and the adoption of proper methods of soil treatment would undoubtedly bring about greater income from the growth of crops on many farms.

Some of the soils are not properly drained and when this is the case the first treatment needed for the most satisfactory crop production is the installation of tile. The Clyde silt loam, the Floyd silt loam and the Clyde silty clay loam on the uplands are not adequately drained and these soils are apt to be too wet for the most profitable crop yields. The Bremer soils on the terrace and the Lamoure and Wabash types on the bottoms are apt to be poorly drained. In all these cases artificial drainage will bring about very profitable increases in the yields of general farm crops.

The soils are practically all acid in reaction and hence in need of lime for the best growth of general farm crops, particularly of legumes. The use of lime on acid soils is very desirable. All the soil types in Floyd County should be tested for acidity or lime requirement and the amount of lime shown to be necessary according to the tests should be applied if the most satisfactory yields of general farm crops are to be secured.

Many of the soils seem to be very well supplied with organic matter and nitrogen but in many cases, especially on the coarser textured sandy types, there is no large content of these constituents and there may even be a deficiency. In such cases, the use of fertilizing materials supplying these constituents is very necessary and on all the soils in the county it is important that such fertilizing materials be applied regularly in order that the supply may be kept up and thus insure the permanent fertility of the soils. The liberal application of farm manure to the soils is very desirable in order to build up and maintain the supply of organic matter and nitrogen. Even on those types which are richer in fertility and darker in color the use of farm manure has been found to bring about large crop increases. Wherever farm manure is not available in sufficient amounts to supply all the soils, the use of leguminous crops as green manures is strongly recommended. When legumes are well inoculated they take a large part of their nitrogen from the atmosphere and hence the use of such crops for green manuring will build up the nitrogen content of the soil. There are many cases in Floyd County where the practice of green manuring would bring considerable returns. The thoro utilization of all crop residues is very necessary on all the soils of the county to aid in maintaining the supply of organic matter and nitrogen.

The phosphorus content of the soils is rather low in most cases and it seems quite evident that applications of phosphorus fertilizers will be needed in the very near future. There are indications, however, from the greenhouse and field experiments carried out on the same soil types occurring in other counties, that the use of a phosphate fertilizer might be of value on some of these soils at the present time. Whether rock phosphate or acid phosphate should be employed cannot yet be definitely stated. Experiments have indicated the value of both materials. Tests of both phosphates are recommended on individual farms.

The use of complete commercial fertilizers cannot be recommended generally at the present time. Experiments which have been carried out indicate that acid phosphate or rock phosphate may give quite as beneficial effects on general farm crops and hence their use will be more profitable because of the greater cost of the complete fertilizers. Tests of complete fertilizers should always be carried out on small areas before there is any extensive application and these tests should compare the effects of the complete fertilizer with the effects of a phosphate in order to determine which would be the better for general use. If the tests indicate profitable returns from the use of the complete fertilizer, there can be no possible objection to the application.

The use of commercial nitrogenous fertilizers does not seem to be necessary in the county at the present time. In most cases where the nitrogen content is not as high as it should be, the use of farm manure and the turning under of leguminous crops as green manures will build up the nitrogen supply quite satisfactorily and economically. The application of commercial nitrogen is expensive and it is questionable whether the crop increases would be great enough to make the application profitable. Tests should certainly be carried out with such materials before there is any general use.

Commercial potassium fertilizers probably will not prove economically profitable on the soils of the county at the present time. In general there is a large supply of potassium in the soils and a potassium fertilizer would not be expected to be economically profitable. Tests of muriate of potash may be carried out, however, on a small scale by any who are interested and if large crop effects are secured, then more general use of muriate of potash may be made.

Erosion occurs to only a limited extent but there are a few cases where considerable washing of the surface soil has occurred and in some areas gullying has been noted. Wherever the destructive action of erosion has taken place, it is important that some means to prevent and remedy the effects of the action should be adopted.

THE GEOLOGY OF FLOYD COUNTY

The geological history of Floyd County is of little significance from the standpoint of the soils occurring in the county at the present time. It is of interest only insofar as the glacial and loessial periods are concerned. The bed rock underlying the soils of the county has been so deeply buried by the deposits of glacial drift or till and by the later deposits of wind blown material or loess, that it has had no appreciable influence on the soils. In only one or two cases have the underlying rocks influenced the soils particularly. This is true in the case of the Dodgeville and Roseville soils, both of which are formed on limestone rock. These two soils have been largely formed from glacial material and only in the subsoil is there any influence of the underlying limestone rock.

At least twice during the glacial age, great ice sheets swept across Floyd County and upon their retreat, these glaciers left behind vast masses of drift material or debris, known as glacial till. The earlier glacier known as the Kansan, extended over the entire county but in practically all parts of it this earlier drift deposit was buried by the deposits of the later glacier. This earlier Kansan

deposit consisted mainly of a blue clay containing numerous boulders and much sand and gravel. The depth of the deposit is extremely variable, ranging from a few feet to many feet in some areas. When weathered the Kansan drift changes to a yellowish-brown to yellow or reddish-yellow in color, and the addition of organic matter has brought about some darkening in the drift material. The earlier topographic features of the county were largely obliterated by this glacier. The soils of the Lindley series are derived partly from the Kansan drift material.

The second great glacier which swept over the county is known as the Iowan. The deposits left by this glacier buried the earlier Kansan drift to a considerable depth in practically all parts of the county. The unweathered Iowan drift material is a bluish-gray or drab clay. Thru oxidation it has changed to a brown or yellowish-brown in color. The texture ranges from a heavy clay to a sandy or gravelly clay. Pockets of sand and gravel are found and boulders of varying size occur over the surface and thru the drift material. The depth of the Iowan drift deposit is extremely variable and it is much thinner on the tops of the old ridges while in the older depressions the depth is considerable. Practically all of the upland soils of the county are derived from this Iowan drift deposit. The soils of the Carrington, Clyde, Floyd, Lindley, Dodgeville, and Dickinson series are all formed entirely or in large part from the Iowan drift deposit.

Long after the deposit of the Iowan drift material, in a later geological age, there was deposited over a limited area in the county, a layer of so-called loess, laid down by the wind. There is only a small area of this loess or silt-like material. It occurs on the east bank of the Cedar River in the vicinity of Floyd. It is somewhat variable in depth, averaging about 15 feet in thickness, and thinning out somewhat toward the east. In color the loess is a light brown to gray or grayish-brown and the subsoil is similar in texture and somewhat lighter in color. The soils of the Clinton series are derived from this loessial deposit.

The soils on the terraces and bottomlands in the county are derived almost entirely from the glacial drift from the uplands.

PHYSIOGRAPHY AND DRAINAGE

The topographic conditions in Floyd County are quite variable. Originally it was a broad drift-covered plain, rather level to flat. But in the ages which have elapsed since the laying down of the drift, much erosion has occurred and the surface topography has been very much modified. Along the Cedar and Shellrock Rivers which flow in a southeasterly direction thru the county, the topography is more strongly rolling except on the west side from Charles City and Marble Rock south, where the topography is gently rolling. In this area along the Cedar and Shellrock Rivers the slopes are often steep and broken and badly gullied and in a number of places limestone appears at the surface, the bluffs rising from 10 to 20 feet from the streams. Similarly along the little Cedar River, Lime, Beaver and Beemis Creeks and Ackley Run, there are small areas where the land is rather rough to broken. These areas, however, are generally narrow and rarely extend back for more than a mile into the upland. There they join the more gently rolling topography which predominates in most of the

upland areas in the county. In general thruout the uplands, the topography is very gently rolling to undulating and the areas between the streams are broad and the slopes to the shallow valleys are long and gentle. This is the characteristic topography for the greater part of Cedar, Rudd and Rock Grove Townships, and western part of St. Charles and Ulster Townships.

Terraces and bottomlands are found developed rather extensively along most of the streams of the county. The largest areas of bottomland soil are found along the Shellrock River from two and a half miles north of the junction of this river and Lime Creek to a point about a mile and a half northwest of Marble Rock and along Cedar River from Charles City north to Floyd. Here there are areas of terrace lands and bottomland soils, varying in width from one to two and a half miles. Along the smaller streams the areas of terrace and bottomland are much narrower, varying between 150 feet and a mile in width. Along the smaller creeks and streams the valleys are shallow and the surrounding country has a slightly rolling to flat appearance. The larger rivers and creeks, however, have cut valleys 30 to 100 feet below the level of the uplands. Here there has been more erosion and the topographic features are more strikingly developed.

The drainage of the county is brought about by the Cedar and Shellrock Rivers and their tributaries. The principal tributary streams are Lime, Flood, Beaver and Beemis Creeks and Ackley Run, which flow into the Shellrock River and the Little Cedar River which joins the Cedar River just outside of the county.

The natural drainage system is fairly adequate as is indicated on the accompanying drainage map. There are some parts, however, where drainage is not sufficient. In the vicinity of the smaller creeks and streams and at the heads of drainageways, the topography is more level and the run-off is slow or restricted and the soils are not adequately drained. In such areas the installation of tile would be valuable in removing the excess water. The soils which have been mapped in the Clyde and Floyd series on the uplands are particularly in need of drainage. The Bremer types on the terraces and the Wabash and Lamoure soils on the bottoms are in need of drainage.

THE SOILS OF FLOYD COUNTY

The soils of Floyd County are grouped into four classes according to their origin and location. These groups are drift soils, loess soils, terrace soils and swamp and bottomland soils. Drift soils are those which have been formed from deposits left by glaciers upon their retreat and consist of materials derived from various sources, usually including pebbles and boulders. Loess soils are fine silt-like deposits made by the wind at some time when climatic conditions were somewhat different than at present. Terrace soils are old bottomlands which have been raised above overflow by a depression in the volume of the streams by which they were formed or by a deepening of the stream channels. Swamp and bottomland soils are those occurring in low poorly drained areas along streams and they are subject to more or less frequent overflow. The total acreage and percent of the area of the county included in each of these four groups of soils are given in table II.

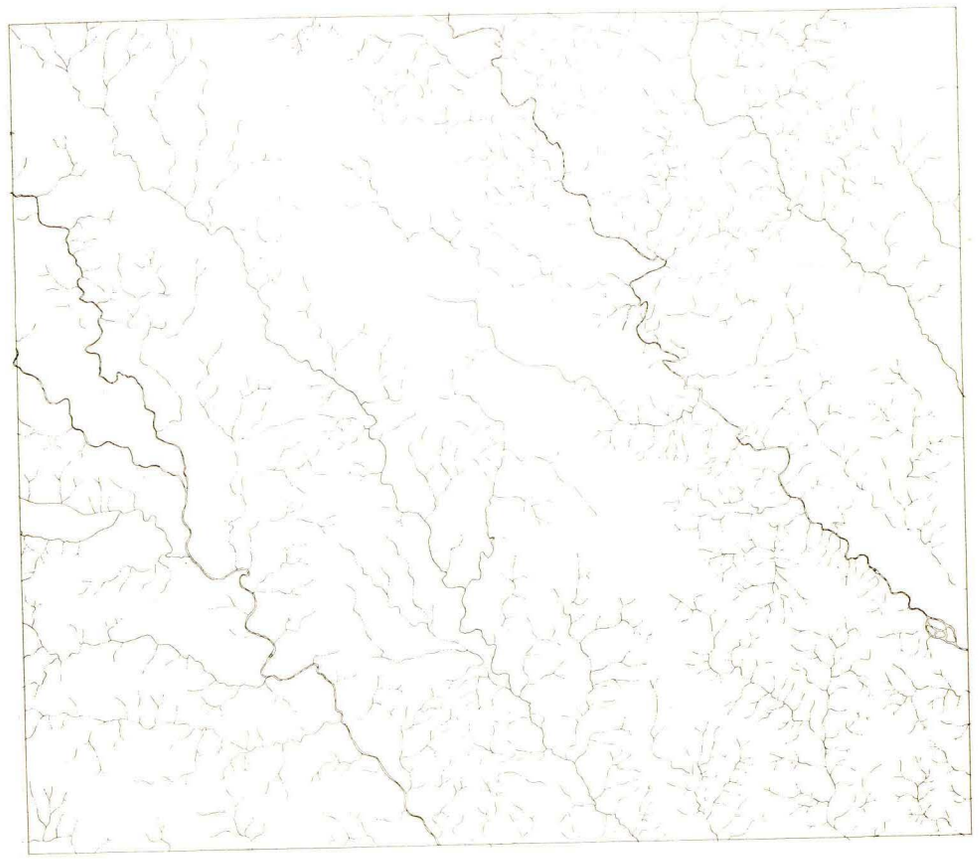

Fig. 2. Map showing the natural drainage system of Floyd County.

More than three-fourths or 83.7 percent of the total area of the county is covered by the drift soils. There is only a very limited occurrence of loess, covering only 0.3 percent of the total area. The terrace soils are rather extensively developed, covering 11.9 percent of the county. The swamp and bottomland types are of limited significance, covering 4.1 percent of the total area.

There are 23 individual soil types and these with the areas of meadow and peat and muck make a total of 25 soil areas. There are 10 drift soils, one loess type, nine terrace soils, and five areas of swamp and bottomland including the meadow and peat and muck. The areas covered by the individual soil types in the county are shown in table III.

The Carrington silt loam is by far the most extensively developed soil type, covering 51 percent of the total area. The Clyde silt loam is the second largest

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

Soil Group	Acres	Percent of total area of county
Drift soils	265,344	83.7
Loess soils	960	0.3
Terrace soils	37,440	11.9
Swamp and bottomland soils	13,056	4.1
Total	316,800	...

soil type and the second most important drift soil, covering 14.2 percent of the county. The third largest type is the Floyd silt loam covering 7.7 percent of the total area. It is the third largest drift soil. The Lindley silt loam, the fourth drift type, covers 3.1 percent of the area. The Dodgeville silt loam covers 2.7 percent, the Carrington loam 2.0 percent, the Dickinson fine sandy loam 1.6 percent of the area. The three remaining drift soils, the Clyde silty clay loam, Dickinson loam and Roseville silt loam each covers less than one percent of the county.

There is only one loess type and it covers only 0.3 percent of the total area. The O'Neill loam is the most extensively developed terrace soil, covering 4.1 percent of the county. The O'Neill silt loam is the second largest terrace soil, covering 2.9 percent of the area. The Waukesha silt loam covers 2.1 percent. The remaining terrace soils are all of minor importance, covering less than one percent of the total area. The Wabash silt loam is the most extensively developed bottomland soil, covering 2.6 percent. The remaining bottomland types cover one percent or less of the total area.

Certain rather definite relationships appear between the topographic features of the county and the individual soil types which have been mapped on the uplands. The soils of the Carrington series are found on the more gently undulating to rolling uplands. The Clyde and the Floyd soils are found in the level

TABLE III. AREAS OF DIFFERENT SOIL TYPES IN FLOYD COUNTY

Soil No.	Soil Type	Acres	Percent of total area of county
	DRIFT SOILS		
83	Carrington silt loam	161,472	51.0
84	Clyde silt loam	44,992	14.2
198	Floyd silt loam	24,448	7.7
32	Lindley silt loam	9,792	3.1
204	Dodgeville silt loam	8,576	2.7
1	Carrington loam	6,400	2.0
175	Dickinson fine sandy loam	5,120	1.6
85	Clyde silty clay loam	2,880	0.9
174	Dickinson loam	1,216	0.4
205	Roseville silt loam	448	0.1
	LOESS SOILS		
80	Clinton silt loam	960	0.3
	TERRACE SOILS		
108	O'Neill loam	12,992	4.1
206	O'Neill silt loam	9,088	2.9
75	Waukesha silt loam	6,656	2.1
88	Bremer silt loam	2,816	0.9
126	O'Neill sandy loam	2,560	0.8
38	Buckner loam	2,240	0.7
45	Buckner fine sandy loam	512	0.2
188	Millsdale loam	320	0.1
46	Buckner fine sand	256	0.1
	SWAMP AND BOTTOMLAND SOILS		
26	Wabash silt loam	8,256	2.6
49	Wabash loam	3,264	1.0
20	Meadow	832	0.3
21	Peat and muck	384	0.1
111	Lamoure silty clay loam	320	0.1
	Total	316,800	

to flat or depressed areas. The Lindley, Dodgeville, Dickinson and Roseville types are found on the more strongly rolling areas and in the case of the Lindley soils, particularly, the topography has become strongly rolling to rough. The Clinton silt loam on the loessial uplands has a strongly rolling topography.

On the terraces and bottoms the topographic features are little developed. The Bremer types are found on the more level terraces, while the O'Neill, Waukesha and Buckner soils are found on the higher terraces. Occasionally some topographic variations occur on these higher, older terrace formations. On the bottomlands the topography is level to flat and there is very little evidence of any topographic effect on the soil types.

THE FERTILITY IN FLOYD COUNTY SOILS

Samples were taken for analysis from all the soil types in the county. The areas of meadow and peat and muck were not sampled because of their great variability and because of the fact that the analyses would mean little. All samplings were made with the greatest care that the samples should represent the soil types and that any variations due to local conditions or previous treatments should be eliminated. Samples were taken at three depths, 0–6 2/3 inches, 6 2/3 to 20 inches, and 20 to 40 inches, representing the surface soil, the subsurface soil and the subsoil respectively.

The total phosphorus, total nitrogen, total organic carbon, total inorganic carbon content and the limestone requirements of the soils were determined. The official methods were used for the phosphorus, nitrogen and carbon, and the limestone requirement determinations were made by the Truog qualitative test. The figures given in the tables are the averages of duplicate determinations on all samples of each type.

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 soils is extremely variable, ranging from 606 pounds in the Lindley silt loam up to 2,259 pounds in the Buckner loam. No relationship is evident between the content of phosphorus in the soils and the various soil groups. The terrace and bottomland types are a little better supplied than the uplands but this might be expected because of the fact that there has been less crop production on these areas than on the upland and hence there has been a smaller removal of the plant food constituents. In general, however, there seems to be a wider variation in phosphorus content within the soil groups than among the various groups of soils.

Some interesting relationships are evidenced, however, between the phosphorus content of the individual soils and the soil series. For example, on the uplands the Clyde soils are the richest in phosphorus of any of the types. The Floyd soils, the Carrington types and the Dickinson types are very similar, the Floyd averaging somewhat higher than the other two series. The Lindley, Dodgeville and Roseville soils are very low in phosphorus. The Clinton silt loam on the loessial upland is more poorly supplied with the element than are the

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

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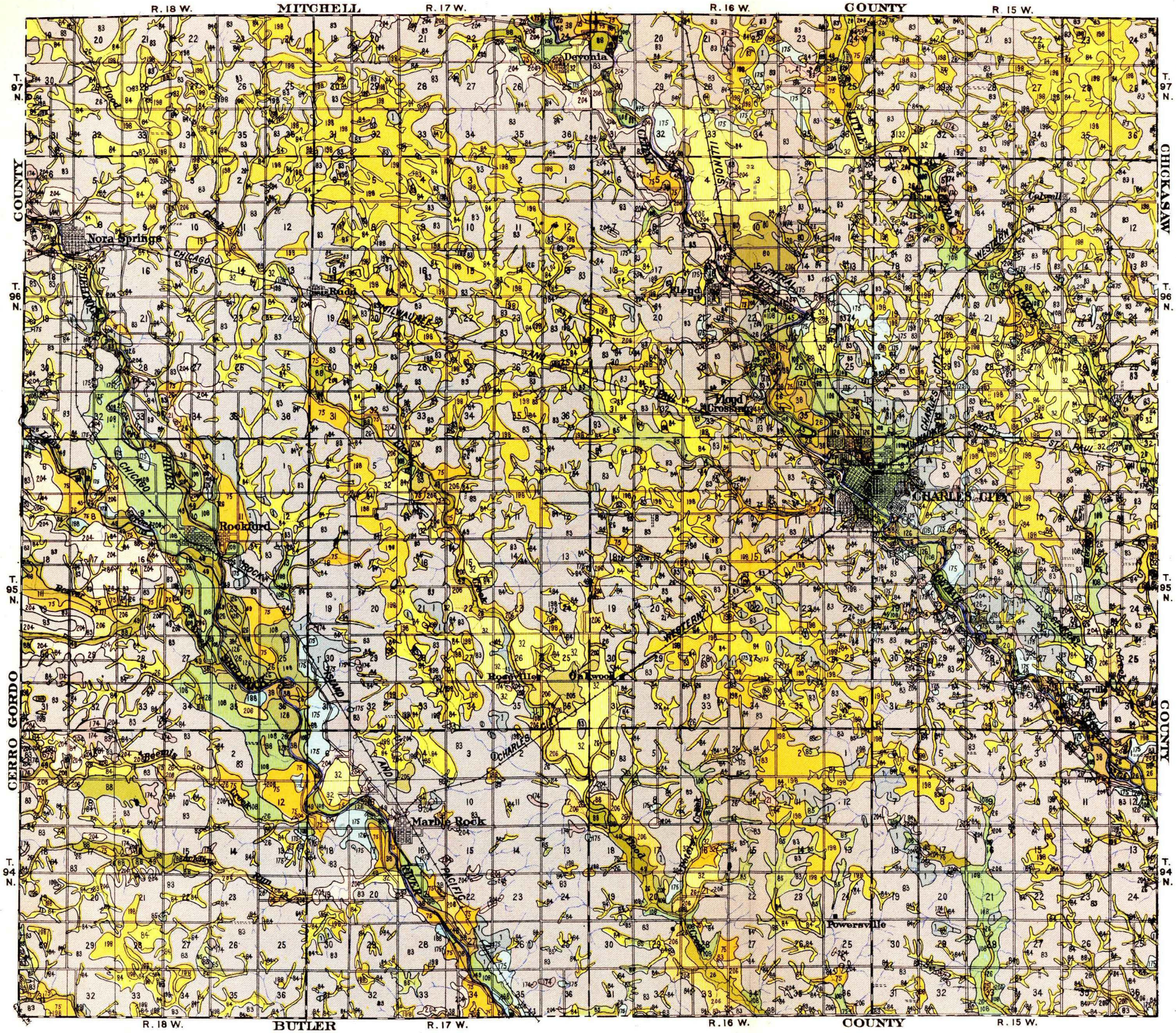
P. E. Brown, Associate in Charge

SOIL MAP OF FLOYD COUNTY, IOWA

Thomas D. Rice, Inspector Northern Division. Soils surveyed by A. M. O'Neal of the Iowa Agricultural Experiment Station and A. W. Goke of the U. S. Dept. of Agriculture.



LEGEND

Drift Soils

83 Carrington silt loam			
175 Dickinson fine sandy loam	84 Clyde silt loam	85 Clyde silty clay loam	
198 Floyd silt loam	174 Dickinson loam	32 Lindley silt loam	
205 Roseville silt loam	204 Dodgeville silt loam	1 Carrington loam	

Loess Soil

80 Clinton silt loam

Terrace Soils

108 O'Neill loam	38 Buckner loam	206 O'Neill silt loam
45 Buckner fine sandy loam	75 Waukesha silt loam	188 Millsdale loam
88 Bremer silt loam	46 Buckner fine sand	126 O'Neill sandy loam

Swamp and Bottomland Soils

26 Wabash silt loam	49 Wabash loam
20 Meadow	21 Peat and Muck
111 Lamoure silty clay loam	

SCALE: 1 INCH TO 2½ MILES

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TABLE IV. PLANT FOOD IN FLOYD COUNTY, IOWA, SOILS
Pounds per acre of two million pounds of surface soil (0–6⅔″)

Soil No.	Soil Type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
	DRIFT SOILS					
83	Carrington silt loam	1,071	4,600	47,707	.....	6,400
84	Clyde silt loam	1,279	5,440	70,450	.....	2,000
198	Floyd silt loam	1,185	6,840	81,530	.....	....
32	Lindley silt loam	606	1,240	14,164	.....	1,000
204	Dodgeville silt loam	791	3,870	39,219	.....	6,000
1	Carrington loam	740	3,260	38,168	.....	2,000
175	Dickinson fine sandy loam	922	2,500	28,198	.....	3,000
85	Clyde silty clay loam	1,690	7,460	75,162	.....	....
174	Dickinson loam	1,272	5,160	56,984	.....	6,000
205	Roseville silt loam	532	2,980	29,430	.....	5,000
	LOESS SOILS					
80	Clinton silt loam	889	3,060	47,722	.....	4,000
	TERRACE SOILS					
108	O'Neill loam	828	2,620	30,046	.....	5,000
206	O'Neill silt loam	946	2,320	29,307	.....	3,500
75	Waukesha silt loam	1,118	3,920	149,408	.....	5,000
88	Bremer silt loam	1,992	4,640	55,352	.....	6,000
126	O'Neill sandy loam	1,286	3,700	41,160	.....	6,000
38	Buckner loam	2,259	7,720	92,346	.....	5,000
45	Buckner fine sandy loam	1,771	3,780	15,462	.....	....
188	Millsdale loam	1,098	4,180	53,972	.....	1,000
46	Buckner fine sand	1,467	3,520	34,869	.....	2,000
	SWAMP AND BOTTOMLAND SOILS					
26	Wabash silt loam	1,957	5,260	78,266	.....	3,000
49	Wabash loam	1,394	4,120	55,352	.....	2,000
111	Lamoure silty clay loam	1,966	10,080	34,360	4,560	....

drift soils of the Clyde, Floyd, Dickinson and Carrington series. On the terraces the Buckner and Bremer soils are better supplied with phosphorus than are the other types. The O'Neill soils are the most poorly supplied with this constituent. On the bottoms there is very little difference between the content of phosphorus in the Wabash and Lamoure soils.

Apparently these differences in phosphorus content reflect the effect of the characteristics which are used as a basis for the differentiation of the soil series. Thus differences in the color of the soils, in the topographic position and in the subsoil characteristics are reflected in the variations in phosphorus content. Those soils like the Clyde and Floyd on the drift upland, and the Buckner and Bremer on the terraces, which are black in color and more level or depressed in topography and with heavy textured subsoils, are richer in phosphorus than are the lighter colored soils like the Carrington, Dickinson, and Lindley on the drift uplands and the O'Neill on the terraces which are more gently undulating to rolling in topography and with lighter textured or coarser textured subsoils. In general it would seem that previous conclusions along this line are borne out by the data presented here in indicating the fact that the soils which are darker in color, more level to depressed in topography and with heavier subsoils, are richer in plant food constituents than are the lighter colored types on the more rolling areas or with coarse textured sandy or gravelly subsoils.

A few comparisons may be made from the data given of the effect of differences in texture of the soils within the series on the phosphorus content. On the

uplands the Carrington silt loam is richer in phosphorus than is the Carrington loam. The Clyde silty clay loam is higher in this element than is the Clyde silt loam. The Dickinson loam is better supplied with phosphorus than the Dickinson fine sandy loam. On the terraces, the O'Neill silt loam is richer in phosphorus than the O'Neill loam. The Buckner loam is much higher than the fine sandy loam or the fine sand, and the fine sandy loam is richer in phosphorus than the fine sand of the same series. There is only one exception to this general relationship and that is in the case of the O'Neill sandy loam which shows a higher content of phosphorus than either the loam or silt loam of the same series. This is probably due to some abnormality in the particular sample. In general it would seem that these analyses bear out previous conclusions along this line, in indicating that soils which are finer textured are better supplied with plant food than are those which are coarser textured. Silty clay loams are ordinarily higher in phosphorus and other plant food elements than are silt loams or other coarser textured types. Silt loams are better supplied than loams and loams are richer than sandy loams or sands. Frequently there are much wider variations in content of plant food in soils because of differences in texture than because of differences in series in which the soils are mapped. The textures may be considered, therefore, as often the determining factor in the plant food content of soil.

The phosphorus content of the soils of the county is generally rather low and in no case is there any large supply. It seems evident that the application of a phosphorus fertilizer will certainly be needed on these soils in the very near future. Experimental work that has been carried out on some of the soils of this county has indicated the value of the application of rock phosphate or acid phosphate now.

The nitrogen content of the soils of the county varies considerably, the amount present ranging from 1,240 pounds in the Lindley silt loam up to 10,080 pounds in the Lamoure silty clay loam on the bottomland. No definite relation between the nitrogen content of the soils and the various groups is evident. The terrace and bottomland types are a little better supplied on the average than are the upland soils, and this might be expected, due to the fact, that there has been less crop growth on the bottomland soils and hence a smaller removal of the element. In general, however, there are greater differences between the nitrogen content of different soils in the same group than between groups.

There are certain differences, however, in the nitrogen content of the soils of the county which seem to be related to the characteristics which are used as the basis for the separation of the various soil series. Thus on the drift uplands the Clyde soils and the Floyd soils are richer than the other upland types. The Carrington soils are better supplied with nitrogen than are the Dodgeville, Lindley or Roseville types. The Lindley is the poorest supplied of any of the upland soils; the Dickinson is somewhat richer in nitrogen than the Roseville and about the same as the Dodgeville. On the terraces the differences are not very significant. One of the Buckner soils is very high in nitrogen and this makes the average of this type somewhat higher than those of the Bremer and the Waukesha soils. Ordinarily the latter would be better supplied with nitrogen than the Buckner. All three groups of soils are, however, richer in nitrogen

than are the O'Neill soils. The Millsdale is about the same as the Waukesha and Bremer. On the bottoms the Lamoure silty clay loam is very much richer in nitrogen than are the Wabash types. This, however, is not entirely due to the series but also to the heavier texture of the Lamoure soil. It is apparent, however, from these comparisons that the color of the soil, the topographic condition, and the subsoil characteristics serve in a large measure to determine the nitrogen content of the soil. Those types which are dark in color, level in topography and with heavy subsoils, like the Clyde, Bremer, and Lamoure will naturally be higher in nitrogen content.

Some interesting correlations are also shown between the texture of the soils and their nitrogen content. The Carrington silt loam is higher in nitrogen than the Carrington loam. The Clyde silty clay loam is better supplied than the Clyde silt loam. The Dickinson loam is higher in this element than the Dickinson fine sandy loam. On the terraces the Buckner loam is better supplied than the fine sandy loam or the fine sand. The O'Neill loam is a little bit higher than the O'Neill silt loam but the difference is not great. The Wabash loam is a little higher on the bottoms than the Wabash silt loam, probably due to some abnormal condition in the particular sample. In general, however, it appears quite evident that on those soils which are finer in texture, there is a higher content of nitrogen; thus silty clay loams are ordinarily higher than silt loams, silt loams are better supplied than loams and the latter soils are richer in the element than sandy loams or fine sandy loams. The ordinary relationship in this particular is borne out by the data secured in this work.

Most of the soils of the county seem to be fairly well supplied with nitrogen. In a few cases the content is low as for example, in the Lindley silt loam and in the sandy loams, the fine sandy loams and fine sands. All these coarser textured types are inclined to be lacking in this essential plant food constituent. Even on the types which are better supplied, however, nitrogen must not be overlooked in planning systems of permanent fertility for the soils of the county. Nitrogen is removed constantly by the growth of plants, and by leaching in the drainage water, and some nitrogenous fertilizer must be employed to return nitrogen to the soil at regular intervals if the supply is to be kept up. It is very important on all the soils of Floyd County that some nitrogen-containing fertilizer be applied regularly to maintain the supply of this element, but on the coarse-textured types applications of nitrogenous fertilizers are necessary at the present time.

The cheapest and best means of supplying nitrogen to the land is by the use of farm manures or green manures. The use of leguminous crops as green manures is an important method of supplementing the use of farm manure in order to build up and keep up the nitrogen content of the soil.

The total organic carbon content of the soils, or the organic matter supply varies considerably; the range is from 14,164 pounds in the Lindley silt loam up to 149,408 pounds in the Waukesha silt loam.

Very much the same relationship may be noticed here as in the case of the nitrogen. No apparent relationships to the soil groups are noticed except that the bottomland types are on the average somewhat better supplied with organic matter than the upland soils. There are, however, rather definite relations between the organic carbon content and certain of the other characteristics which serve to

determine the soil series. It would appear that those soils which are dark in color, level in topography, and with heavy textured subsoils are richer in organic matter than those types which are light in color, more rolling in topography, and with light or coarse-textured subsoils. For example, on the drift upland, the Clyde, and Floyd soils are much better supplied than the other types. The Carrington soils are somewhat better supplied than the Dickinson types; the latter contain more organic matter than the Dodgeville and Roseville soils. On the terraces some of the samples were evidently somewhat abnormal. The Waukesha silt loam shows a very high content of organic matter, much higher than usual, and the Buckner loam is very high, abnormally high in organic matter. This same type was also very high in nitrogen, indicating an abnormal sample. Ordinarily, the Bremer and Waukesha soils show a higher organic matter content than the Buckner or O'Neill types. The Buckner is ordinarily better supplied than the O'Neill, and this seems to be true in this county. On the bottomlands the Wabash soils are better supplied than the Lamoure, but again this is a difference which is not characteristic of these types, but is due more to the particular condition of the individual samples which were analyzed. Apparently, however, the relationship mentioned between color, topography and subsoil character are borne out by the results of these analyses.

The relationship to texture, which was noted in the case of nitrogen, is very similar in the case of the organic matter content. Thus the Carrington silt loam is higher in organic matter than the Carrington loam. The Clyde silty clay loam is richer than the Clyde silt loam. The Dickinson loam is better supplied than the Dickinson fine sandy loam. The Buckner loam is richer than the fine sandy loam and fine sand. The O'Neill soils are not very different in their organic matter content. On the bottoms the Wabash silt loam is richer than the Wabash loam. It is apparent, therefore, that fine textured types are better supplied with organic matter than coarse textured ones. Thus silty clay loams are higher than silt loams, the latter are better supplied than loams and loams are richer in organic matter than the sandy types.

Some of the soil types in this county are not very well supplied with organic matter. The majority are dark in color and fairly well supplied with this constituent. On those types which are lighter, it is very important that applications of organic matter be made at the present time to build up the supply of this constituent. On all the soils, however, applications of organic matter are necessary in order to keep up the supply of this constituent.

The use of farm manure has proven to be valuable even on those types which are apparently richer in organic matter and black in color. Where farm manure is not available for use or where the supply is inadequate, the turning under of leguminous crops as green manures is very necessary. The utilization of all crop residues is also necessary in order to maintain a supply of organic matter in the soils.

The rate at which the various plant foods constituents in the soils are made available is indicated by the relationship between the total organic carbon content of the soils and their supply of nitrogen. When this relationship is not at the best, there will be too slow a production of available plant food to keep crops properly supplied. In some of the types in Floyd County, this relationship is very poor. Thus the Carrington silt loam, the Lindley silt loam, the Dodgeville silt loam, the Carrington loam, the Dickinson fine sandy loam, the Clyde silty clay loam, the Dickinson loam and the Roseville silt loam and indeed practically all of the upland drift soils in the county show a poor relationship between nitrogen and carbon and hence, a low production of available plant food. A number of the soils on the terraces likewise show a poor relationship between nitrogen and carbon. This is true of the O'Neill loam and silt loam and the Buckner fine sandy loam, and fine sand. On all these types, the application of farm manure will be particularly valuable. Farm manure supplies the soils, not only with organic matter and certain essential plant food constitutents, but it adds large numbers of microorganisms, which bring about an increase in the production of available plant food in the soil.

The soils of the county, with one exception, are all acid in reaction, in the surface soil and are in need of lime. In some cases, the lime requirement is very low and in other cases it runs rather high. The figures given for the lime requirements should, however, be considered merely indicative of the lime needs of the individual soil types. There is such a wide variation in the lime requirements of different soil types and even of different samples of the same type and in different fields that the figures given should be taken to show only roughly the requirements of these soils. It is very important that all the soils in the county, except the Lamoure silty clay loam, be tested for their lime needs before any application of that material is made. In fact soils from each individual field should be tested in order that the proper amount of lime may be applied. The Lamoure silty clay loam is the only type which contains any inorganic carbon in the surface soil. It is the only type, therefore, which does not need to be tested and to receive applications of lime.

The data given here emphasize the fact that the soils of this county in general are in need of lime if the best growth of general farm crops, and particularly of legumes is to be secured. Farmers of the county should be sure that their soils are tested for lime needs, and that the amount of lime shown to be necessary by the tests is applied if they expect to secure the best crop growth.

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 soil and 6,000,000 pounds of subsoil per acre.

The conclusions which have been drawn regarding the needs of the soils of the county from the analyses of the surface soils are very largely confirmed by the figures given for the subsurface soils and subsoils. It will not be necessary, therefore, to consider the results of these analyses in detail.

The analyses of these soils show that there is no large content of phosphorus in the lower soil layers in this county, and, hence, it is apparent that applications of phosphate fertilizers will certainly be needed on these types in the very near future, even if their use is not of value at the present time. Crops will not be supplied with any large amount of this constituent from the lower soil layers. Hence, the needs of the surface soils for this constituent are emphasized

by these analyses. The use of a phosphate fertilizer on the soils of this county is, therefore, strongly to be recommended.

Many of the soil types have an adequate supply of nitrogen and organic carbon, but some are not very well suplied. It is important, therefore, that some means be taken to keep up the content of these constituents if the soils are to remain satisfactorily productive. Those types which are deficient in nitrogen and organic matter in the surface soils show likewise a deficiency in the lower soil layers. Those types which are fairly well supplied in the surface show no large content below. It is important, therefore, that farm manure, leguminous green manures, and crop residues all be utilized on the soils of this county in order to maintain the supply of organic matter and to aid in keeping up the content of nitrogen.

The need of lime on all the soils of the county, except the Lamoure silty clay loam, is emphasized by the results given for the lower soil layers. Only in one case is there any high lime content in the lower soil and that is in the subsoil of the Dodgeville silt loam, which really consists of a mixture of lime rock with the subsoil material. It is apparent, therefore, that the soils of this county with the exception of Lamoure silty clay loam should all be tested for lime requirement and that applications of lime should be made regularly as needed in order that the soils may be put in the best condition for the growth of general farm crops, and particularly for the best growth of legumes.

TABLE V. PLANT FOOD IN FLOYD COUNTY, IOWA, SOILS

Pounds per acre of four million pounds of subsurface soil (6⅔″–20″)

Soil No.	Soil Type	Total phosphorus	Total nitrogen	Total organic carbon	Total inorganic carbon	Limestone requirement
	DRIFT SOILS					
83	Carrington silt loam	1,584	5,373	50,893	.....	5,000
84	Clyde silt loam	1,467	5,520	64,352	.....	2,000
198	Floyd silt loam	848	3,680	43,596	.....	3,000
32	Lindley silt loam	1,696	840	16,360	.....	7,000
204	Dodgeville silt loam	1,643	5,380	57,128	.....	5,000
1	Carrington loam	1,090	2,920	3,268	.....	2,000
175	Dickinson fine sandy loam	1,764	3,680	38,920	.....	3,000
85	Clyde silty clay loam	2,612	6,920	74,950	.....	....
174	Dickinson loam	2,046	4,800	50,542	.....	5,000
205	Roseville silt loam	510	2,120	16,360	.....	8,000
	LOESS SOILS					
80	Clinton silt loam	996	2,240	45,784	.....	5,000
	TERRACE SOILS					
108	O'Neill loam	1,386	3,680	46,324	.....	4,000
206	O'Neill silt loam	1,347	1,980	23,975	.....	3,500
75	Waukesha silt loam	2,060	5,760	75,536	.....	3,000
88	Bremer silt loam	3,876	9,360	111,798	.....	5,000
126	O'Neill sandy loam	1,588	3,480	41,964	.....	3,000
38	Buckner loam	3,831	12,940	172,013	.....	4,000
45	Buckner fine sandy loam	3,744	9,720	82,696	.....	....
188	Millsdale loam	2,020	5,080	50,680	.....	1,000
46	Buckner fine sand	2,396	5,360	56,652	.....	....
	SWAMP AND BOTTOMLAND SOILS					
26	Wabash silt loam	3,796	10,480	129,554	.....	1,000
49	Wabash loam	1,588	4,560	56,684	.....	....
111	Lamoure silty clay loam	2,518	6,480	69,464	5,240	....

TABLE VI. PLANT FOOD IN FLOYD 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	Limestone requirement
	DRIFT SOILS					
83	Carrington silt loam	2,138	4,127	34,328	.....	3,500
84	Clyde silt loam	2,505	3,360	40,860	.....	....
198	Floyd silt loam	1,776	1,680	8,181	.....	7,000
32	Lindley silt loam	2,745	1,200	8,181	.....	5,000
204	Dodgeville silt loam	565	3,240	22,590	337,410	....
1	Carrington loam	1,414	2,880	29,436	.....	7,000
175	Dickinson fine sandy loam	2,000	2,640	24,540	.....	3,000
85	Clyde silty clay loam	3,111	2,640	24,084	.....	....
174	Dickinson loam	2,353	2,400	23,452	.....	3,000
205	Roseville silt loam	263	1,340	12,266	.....	8,000
	LOESS SOILS					
80	Clinton silt loam	2,301	2,160	41,660	.....	4,000
	TERRACE SOILS					
108	O'Neill loam	1,535	2,640	133,334	.....	2,000
206	O'Neill silt loam	2,108	1,760	80,094	.....	4,000
75	Waukesha silt loam	2,544	5,000	49,320	.....	2,000
88	Bremer silt loam	3,432	7,920	105,045	.....	3,000
126	O'Neill sandy loam	1,737	1,920	16,362	.....	2,000
38	Buckner loam	5,098	14,040	215,461	.....	3,000
45	Buckner fine sandy loam	5,514	10,320	83,066	.....	....
188	Millsdale loam	No sample				
46	Buckner fine sand	2,706	2,760	2,300	.....	....
	SWAMP AND BOTTOMLAND SOILS					
26	Wabash silt loam	3,756	8,760	114,504	.....	1,000
49	Wabash loam	3,150	7,440	98,169	.....	....
111	Lamoure silty clay loam	3,150	5,640	74,081	1,455	....

GREENHOUSE EXPERIMENTS

Two greenhouse experiments were carried out on soil types from Floyd County with the idea of determining the fertilizer needs of these soils, and learning something regarding the response to fertilizer treatment. These experiments were carried out on the Carrington silt loam and the Clyde silt loam, two of the most extensive types in the county. In addition, greenhouse experiments on the Carrington silt loam from Blackhawk County, on the Carrington loam from Marshall County, and on the Carrington silt loam and Clyde silt loam from Linn County are included inasmuch as these soils are the same as those occurring in Floyd County and the results may be considered to indicate, therefore, the effects of the same fertilizer applications on the soils of this county.

These greenhouse experiments have all been carried out according to the same plan, the treatments used being the same as those employed in the field experiments. Manure is added at the rate of eight tons per acre, lime in sufficient amounts to neutralize the acidity of the soil, rock phosphate at the rate of 2,000 pounds per acre, acid phosphate at the rate of 200 pounds per acre and a complete commercial fertilizer, a standard 2-8-2 brand, at the rate of 300 pounds per acre. Wheat and clover were grown in all the pots, clover being seeded about one month after the wheat was up.

TABLE VII. GREENHOUSE EXPERIMENT
Carrington silt loam—Floyd County

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	6.9	11.6
2	Manure	8.4	14.4
3	Manure+lime	10.2	15.6
4	Manure+lime+rock phosphate	11.5	18.0
5	Manure+lime+acid phosphate	11.1	23.9
6	Manure+lime+complete commercial fertilizer	11.0	19.2

RESULTS ON CARRINGTON SILT LOAM

The results secured on the Carrington silt loam from Floyd County are given in table VII. The application of manure increased the yields of both the wheat and clover crops to a considerable extent. Lime with the manure increased still further the yields of the two crops. An increase might be expected on the clover of the rotation, but would hardly be looked for on the wheat, but a very beneficial effect was noticed on this wheat crop. Rock phosphate with the manure and lime showed a very considerable increase in the clover crop and brought about an appreciable gain in the wheat. Acid phosphate with the manure and lime showed a very much greater effect on the clover crop but had about the same effect on the wheat as did the rock phosphate. The complete commercial fertilizer with the manure and lime showed about the same effect on the wheat as did the phosphates, but it had a greater effect on the clover than the rock phosphate, tho a smaller influence than the acid phosphate was evident.

The application of manure seems to be particularly valuable on this soil and

Fig. 3. Wheat and clover on Carrington silt loam, Floyd County.

Fig. 4. Clover on Carrington silt loam, Floyd County.

large increases in the yields of general farm crops will be secured from the application of this material. The addition of lime is desirable as the soil is acid in reaction. The application of a phosphate fertilizer is apparently desirable on this soil, the acid phosphate showing much greater effect than the rock phosphate in the case of the clover crop, but having no greater influence on the wheat than did the rock phosphate.

RESULTS ON THE CLYDE SILT LOAM

The results of the greenhouse experiment on the Clyde silt loam are given in table VIII. The beneficial influence of manure on this soil type is evidenced by the increased yields of wheat and clover which were secured in this test. Apparently the use of manure is very desirable on this soil in spite of the fact that it is black in color and apparently very well supplied with organic matter. It is acid in reaction and applications of lime are desirable. The clover crop in this test showed a very considerable increase from the use of lime. No effect was found in the wheat but this is not unusual as frequently applications of lime do not show beneficial effects on the grain crop of the rotation. Lime is always of value, however, on the growth of legume crops. The application of rock phosphate with the manure and lime brought about an increase in the yield of wheat but showed little effect on the clover. The acid phosphate with the manure and lime increased the yield of wheat to a small extent, but brought about a pronounced gain in the yield of clover. The complete commercial fertilizer showed the largest effect on the wheat crop but had a smaller effect on the clover than did the acid phosphate.

This experiment emphasizes the fact that the Clyde silt loam will respond profitably to applications of manure, which should be applied regularly to this soil. The type is not heavy enough in texture, so that the manure would be apt to bring about any undesirable effects upon the small grain crop of the rotation because of lodging, but in order to avoid any possibility of such an influence of the manure, it would be wise to make the application as far away from the small grain crop of the rotation as possible. When applied in this way, the manure certainly will prove of value on this soil. The soil is acid in reaction and additions of lime are necessary. The addition of a phosphate fertilizer is very

TABLE VIII. GREENHOUSE EXPERIMENT
Clyde silt loam—Floyd County

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	4.8	10.1
2	Manure	6.3	14.3
3	Manure+Lime	6.2	16.7
4	Manure+lime+rock phosphate	6.7	16.8
5	Manure+lime+acid phosphate	6.8	20.9
6	Manure+lime+complete commercial fertilizer	7.6	17.7

desirable and tests of rock phosphate and acid phosphate are recommended. These results indicate greater value for the acid phosphate.

RESULTS ON CARRINGTON SILT LOAM FROM BLACKHAWK COUNTY

The results secured in the greenhouse experiment on the Carrington silt loam from Blackhawk County are given in table IX. The beneficial effects of applications of manure on this soil are evident by the increased yields of wheat and clover which were secured, the clover being very largely increased. Lime brought about an increase in the clover but had no effect on the wheat. The rock phosphate applied with the manure and lime had little effect on either crop. The acid phosphate, however, used with the manure and lime increased the yields of both crops to a considerable extent, the effect being particularly evident on the clover crop. The complete commercial fertilizer used with the manure and lime had a greater effect on both the wheat and clover crops than did the acid phosphate. The beneficial effect was very pronounced in the case of the clover.

These results serve to confirm those secured on the same soil type from Floyd

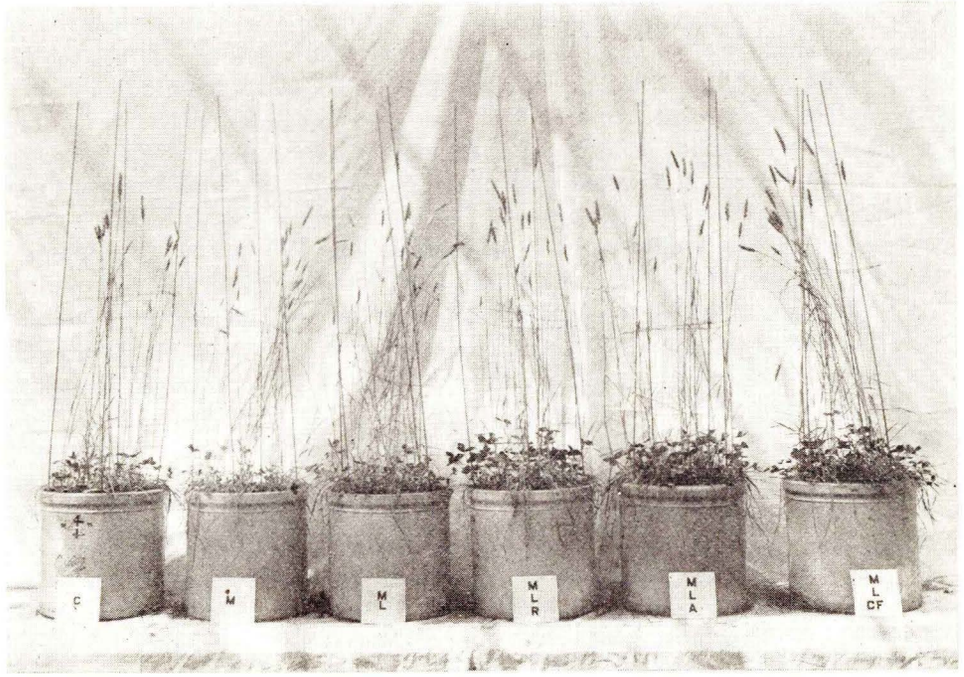

Fig. 5. Wheat and clover on Clyde silt loam, Floyd County.

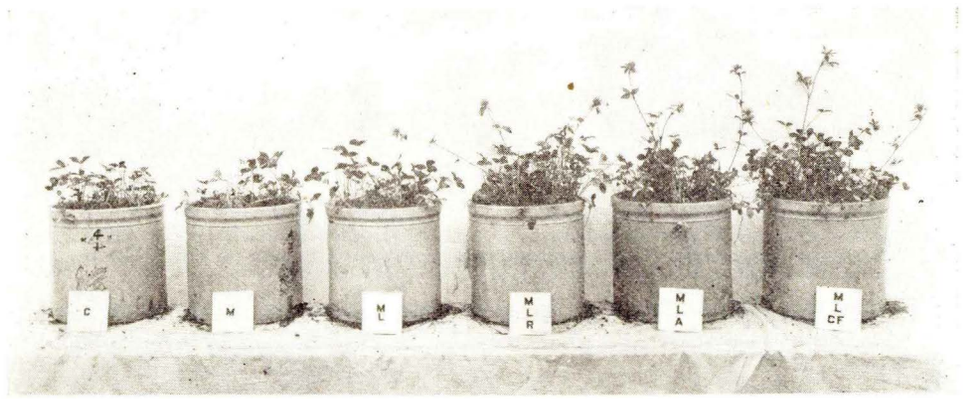

Fig. 6. Clover on the Clyde silt loam, Floyd County.

County. The beneficial effect of manure is definitely shown, the use of lime is valuable from the standpoint of increasing the legume crops and the application of a phosphorus fertilizer would apparently be of value. These results indicate the superiority of the acid phosphate over rock phosphate.

RESULTS ON CARRINGTON LOAM FROM MARSHALL COUNTY

The results secured in the greenhouse experiment on the Carrington loam from Marshall County are given in table X. The value of applying manure to this soil is definitely evidenced in these results. There was a large increase in the wheat yields, and the clover crop was more than doubled by the application of the manure. Lime in addition to the manure had a slight influence on the yield of wheat but showed no effect on the clover. Ordinarily, however, this soil will respond very definitely to applications of lime when legume crops are to be grown, and the use of lime on the type is certainly to be recommended. The rock phosphate, the acid phosphate and the complete commercial fertilizer applied with the manure and lime all brought about distinct increases in the yields of both the wheat and clover crops. There was very little difference in the effect on the wheat, but the acid phosphate showed up very much better than the other two materials in the case of the clover.

It is evident that the Carrington loam will be made much more productive by applications of manure, and the liberal use of this material on this soil is strongly to be recommended. Lime did not show up in this particular test, but there is an abundance of evidence from field experiments to show that large increases are usually secured in the growth of legume crops when lime is applied to this

TABLE IX. GREENHOUSE EXPERIMENT
Carrington silt loam—Black Hawk County

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	12.53	4.5
2	Manure	14.76	15.5
3	Manure+lime	14.67	22.5
4	Manure+lime+rock phosphate	13.93	21.0
5	Manure+lime+acid phosphate	15.22	28.5
6	Manure+lime+complete commercial fertilizer	16.75	36.5

TABLE X. GREENHOUSE EXPERIMENT
Carrington loam—Marshall County

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	16.5	22.68
2	Manure	24.0	45.36
3	Manure+lime	25.0	40.82
4	Manure+lime+rock phosphate	27.0	49.89
5	Manure+lime+acid phosphate	27.5	54.43
6	Manure+lime+complete commercial fertilizer	26.0	49.89

soil. Phosphorus fertilizers will certainly bring about profitable increases on this soil. Acid phosphate seemed to be somewhat preferable in this particular case.

RESULTS ON CARRINGTON SILT LOAM FROM LINN COUNTY

The greenhouse results secured on the Carrington silt loam from Linn County are given in table XI. The application of manure brought about a distinct increase in the yields of both wheat and clover, the effect being particularly noticeable on the clover. When lime was applied in addition to the manure, still further increases were evidenced and in the case of the clover, the increase was very large, indicating the need of lime on this soil type if clover is to be grown most successfully. It is interesting to note that the yield of wheat was also increased by the addition of lime. The rock phosphate, acid phosphate, and complete commercial fertilizer showed very little effect on the wheat crop, altho there is some evidence of value from the acid phosphate. In the case of the clover, however, all three of the materials brought about distinct increases in the yields, the largest effect being evidenced from the acid phosphate.

These results serve to confirm those secured on the same soil type from Floyd County. They indicate the large value of manure as a fertilizing material for this soil. They show that the soil should be tested for acidity, and that lime should be applied as needed if the best growth of leguminous crops is to be secured. There are indications that the use of phosphorus fertilizers is also desirable. Whether acid phosphate or rock phosphate should be employed cannot be definitely stated altho the acid phosphate seemed to show up somewhat better than the rock phosphate.

RESULTS ON CLYDE SILT LOAM FROM LINN COUNTY

The results secured in the greenhouse experiment on the Clyde silt loam from Linn County are given in table XII. Here again the beneficial effect of manure is shown both on the wheat and clover crop. The influence is particularly noticeable in the case of the clover crop. The results for the crops on the pots receiving manure and lime are not given because of some abnormal condition in these pots. The influence of the phosphates and the complete commercial fertilizer is evident on both crops, the acid phosphate showing up somewhat better than the other two materials on the clover, while the complete commercial fertilizer was quite superior on the wheat.

The results secured on the Clyde silt loam from Floyd County are confirmed by these results secured on the same soil type from another county. They in-

TABLE XI. GREENHOUSE EXPERIMENT
Carrington silt loam—Linn County

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	16.74	10.5
2	Manure	18.29	16.0
3	Manure+lime	22.00	28.0
4	Manure+lime+rock phosphate	22.50	32.0
5	Manure+lime+acid phosphate	23.53	34.5
6	Manure+lime+complete commercial fertilizer	21.13	33.0

dicate the beneficial effects of applications of manure even tho this soil is dark in color, apparently rich in fertility and well supplied with organic matter. By practical experience applications of lime have been found to be very desirable especially if legume crops are to be grown. The use of a phosphate fertilizer is to be recommended. These results indicated superiority for acid phosphate, but field experiments might not confirm this observation.

FIELD EXPERIMENTS

A field experiment is being carried out in Floyd County but the results from this field have not been secured over a long enough period of years for the data to be of significance. Experiments have been carried out for several years, however, in adjacent counties on the same soil types as those occurring most extensively in this county. The results which are being secured on some of these fields will be included here, inasmuch as they undoubtedly indicate the effects which may be expected from the same fertilizers on the soils in Floyd County. The results serve to emphasize the needs of the soils of Floyd County, and they also support the suggestion made of the desirability of testing the various fertilizing materials in the county and determining their value.

These field experiments are planned to determine the relative value of various soil treatments. They are laid out on land which is entirely representative of the particular soil types in the county. 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 crops to insure the securing of accurate results. The plots are 155′ 7″ x 28′ or one-tenth of an acre in size.

The fields include tests under the livestock and grain systems of farming. In the former manure is applied, while in the latter crop residues are utilized in place of the manure. Other fertilizing materials tested include limestone, acid phosphate, rock 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

TABLE XII. GREENHOUSE EXPERIMENT
Clyde silt loam—Linn County

Pot No.	Treatment	Weight of wheat grain in grams	Weight of clover in grams
1	Check	13.94	39.0
2	Manure	15.73	62.0
3	Manure+lime	....	...
4	Manure+lime+rock phosphate	15.82	68.0
5	Manure+lime+acid phosphate	16.00	71.0
6	Manure+lime+complete commercial fertilizer	16.49	69.0

added in sufficient amounts to neutralize the acidity of the soil. The crop residues treatment consists of plowing under the corn stalks which have been cut with a stalk cutter and the plowing under of at least the second crop of clover. Sometimes the first crop of clover is cut and allowed to remain on the land to be plowed under with the second. Rock phosphate is added at the rate of 2,000 pounds per acre once in a four-year rotation. Since 1925, this material has been applied at the rate of 1,000 pounds per acre once in four years. Acid phosphate is used at the rate of 150 pounds per acre annually. The standard 2-8-2 complete commercial fertilizer was used until 1923, applications being made at the rate of 300 pounds per acre. Since 1923 the new standard 2-12-2 brand has been applied, applying 202 pounds per acre, thus supplying an equivalent amount of phosphorus to that applied in the 150 pounds of acid phosphate.

THE OSAGE FIELD

The results secured in the field experiment on the Carrington silt loam, Mitchell County on the Osage Field, Series I are given in table XIII. The application of manure to this soil type proved valuable in increasing the crop yields. Only in one season was there no considerable increase in the crops grown. In some cases very large gains were noted as, for example, on the oats in 1920, on the clover in 1921, on the corn in 1922, on the clover and timothy in 1925 and on the corn in 1926. The use of lime with the manure gave further increases in the yields of the crops grown in most seasons. In one or two cases no increases were noted. In general, however, pronounced gains were secured. The corn in 1919 was benefited to a considerable extent. The clover in 1921, the corn in 1923, and the clover and timothy in 1925 were very materially increased by the use of the lime.

The application of rock phosphate with the manure and lime proved of value on practically all the crops grown. Only in one case was there no evidence of increased crop yields. The acid phosphate with the manure and lime showed better results than the rock phosphate in most cases. The oats in 1924 and the clover and timothy in 1925 showed very much larger effects from the acid phosphate than from the rock phosphate. The complete commercial fertilizer with the manure and lime showed somewhat larger effects than the acid phosphate in several seasons. In general, however, the differences were not very great, and in one or two cases the complete commercial fertilizer did not give as large increases on the crops grown as did the acid phosphate.

The crop residues showed little effect on the various crops grown. Lime with the crop residues increased the yields in practically all seasons,. In some instances very large gains were noted as, for example, on the corn in 1919, on the corn in 1923, on the oats in 1924, on the clover and timothy in 1925 and on the corn in 1926.

The rock phosphate with the crop residues and lime showed a beneficial effect on the crops grown in most cases. In one or two instances, large increases were secured as, for example, on the oats in 1920, on the oats in 1924, and on the clover and timothy in 1925. The clover in 1921 was not increased and the corn in 1922 and 1923 showed no beneficial effects from the rock phosphate. The acid phosphate with the crop residues and lime showed a slightly greater effect than did

the rock phosphate in only two seasons. In most cases the benefits were less pronounced than from the rock phosphate, altho generally the differences were not large. The complete commercial fertilizer had a larger effect than the phosphates in most seasons, but the differences were not very great.

These results indicate the value of applying manure to this soil and liberal applications of this fertilizing material will undoubtedly be of value. The soil is acid in reaction and increases in crop yields will be secured from the use of lime. Not only are increases in leguminous crops secured, but the yields of other general farm crops are materially increased. The addition of a phosphate fertilizer proved of considerable value on this type. In some cases, the rock phosphate gave larger returns than the acid phosphate, but in many instances the reverse was true. Definite conclusions cannot be drawn, therefore, regarding the relative value of these two phosphates. The application of a complete commercial fertilizer cannot be recommended for general use on this soil at the present time. It seems from the data presented that acid phosphate will bring about quite as large crop increases.

THE SPRINGVILLE FIELD

The results secured on the Carrington silt loam on the Springville Field Series I in Linn County are given in table XIV. Beneficial effects of manure on this soil are definitely shown by these results. Considerable increases in crop yields were secured from the use of manure in practically all cases. In some seasons

TABLE XIII. FIELD EXPERIMENT, CARRINGTON SILT LOAM, MITCHELL COUNTY

OSAGE FIELD, SERIES I

Plot No.	Treatment	(1) 1918 Corn bu. per A.	1919 Corn bu. per A.	(2) 1920 Oats bu. per A.	(3) 1921 Clover tons per A.	(4) 1922 Corn bu. per A.	(5) 1923 Corn bu. per A.	(6) 1924 Oats bu. per A.	(7) 1925 Clover and Timothy Tons per A.	1926 Corn bu. per A.
1	Check	46.5	55.8	34.6	1.09	58.8	42.3	72.4	0.97	37.3
2	Manure	52.8	60.0	60.3	1.55	68.0	50.8	71.0	1.25	51.4
3	Manure+lime	52.8	70.0	56.3	1.98	68.0	64.1	82.8	1.64	56.0
4	Manure+lime+rock phosphate	54.8	72.0	61.2	1.94	74.3	70.7	86.5	1.68	57.0
5	Manure+lime+acid phosphate	56.4	77.0	61.2	1.82	76.0	70.7	98.0	1.90	55.7
6	Manure+lime+complete commercial fertilizer	44.5	79.0	67.3	1.63	72.3	70.2	102.9	1.92	60.8
7	Check	38.8	67.0	59.8	1.48	50.0	53.7	74.3	1.12	46.6
8	Crop residues	37.7	65.0	55.0	1.55	51.4	52.0	71.8	1.14	41.3
9	Crop residues+lime	39.4	74.0	50.3	1.55	58.3	65.2	81.6	1.63	52.0
10	Crop residues+lime+rock phosphate	47.4	75.0	61.8	1.55	57.7	64.4	90.3	1.94	52.5
11	Crop residues+lime+acid phosphate	44.2	73.0	59.8	1.44	62.3	64.9	78.4	2.07	51.2
12	Crop residues+lime+complete commercial fertilizer	48.8	78.0	67.3	1.79	65.5	69.9	87.1	1.55	50.9
13	Check	39.7	67.0	53.1	1.59	52.3	53.2	75.6	0.88	44.0

1. Four tons lime applied.
2. Plot 1, low yield, oats down badly; four tons lime applied in September.
3. Clover pastured heavily in spring.
4. Corn down badly on checks and crop residue plots.
5. Dry weather reduced yields.
6. Poor stand on plot 11 due to pocket gophers.
7. Clover mostly killed out in spring due to ice sheet, good stand of timothy.

the crops were increased to a large extent, as was the case with the corn in 1923. The application of lime along with the manure increased the crop yields in most seasons. In several cases large benefits were secured from the use of this material as for example on the corn in 1920 and on the oats in 1925.

The rock phosphate with the manure and lime showed very definite increases in crop yields in practically all seasons. In some cases the gains were very striking as, for example, on the clover in 1922 and on the corn in 1923. The acid phosphate with the manure and lime gave larger increases than the rock phosphate in several cases, but in others the rock phosphate proved somewhat superior. The differences were not great, however, in any instance. The complete commercial fertilizer showed slightly smaller yields than the acid phosphate in some seasons, but in other cases had a somewhat larger effect.

The crop residues brought about increases in the yields in most seasons. Lime with the residues had a beneficial effect in several cases, the largest influence being secured on the oats in 1925. Rock phosphate with the crop residues and lime had a beneficial effect on the crop yields in all but two cases. In some seasons the influence was very large as for example on the clover in 1922 and on the corn in 1923. The acid phosphate with the crop residues and lime showed a larger effect than the rock phosphate in several seasons, but in other cases the influence was very much the same as that secured from the rock phosphate. In one case there was a very pronounced difference in favor of the rock phosphate. The complete commercial fertilizer showed a smaller effect than the acid phosphate in most seasons and in two cases where a larger influence was exerted, the differences were not large enough to be of significance.

The results secured on the Carrington silt loam on the Springville Field, Series II, in Linn County are given in table XV. Here again, the beneficial effect of the manure is evidenced in the increased crop yields secured in every season. In some instances as on the corn in 1922, there was a very large gain in the crop growth. Lime with the manure showed a very beneficial effect on the crops grown in practically every case. The clover in 1921 showed the most pronounced increase.

The rock phosphate with the manure and lime increased the crop yields in every season, but in some cases the increases were small. The clover in 1921 was benefited to the largest extent. The acid phosphate, with the manure and lime, showed a greater effect than the rock phosphate in some cases, but in general the influence was less evident except on the clover in 1921. The complete commercial fertilizer showed no better effect than the rock phosphate and the acid phosphate except in the case of the clover in 1921 where it gave a larger increase than did the rock phosphate.

The crop residues showed little effect on the crops secured in most seasons. Lime with the crop residues brought about a definite increase in the crop yields in several cases, the largest influence being noted on the corn in 1926. The rock phosphate with the crop residues and lime increased the yields of crops in practically all cases, showing up particularly well on the clover in 1921. The acid phosphate gave increases in all seasons, having a somewhat greater effect than the rock phosphate in some years as, for example, on the clover in 1925. In other cases the differences were small. The complete commercial fertilizer had a

TABLE XIV. FIELD EXPERIMENT, CARRINGTON SILT LOAM, LINN COUNTY SPRINGVILLE FIELD, SERIES I

Plot No.	Treatment	(1) 1918 Clover tons per A.	(2) 1919 Corn bu. per A.	(3) 1920 Corn bu. per A.	1921 Oats bu. per A.	(4) 1922 Clover tons per A.	(5) 1923 Corn bu. per A.	(6) 1924 Corn bu. per A.	(7) 1925 Oats bu. per A.	(8) 1926 Corn bu. per A.
1	Check	2.25	58.6	46.5	44.8	1.37	40.2	....	53.9	41.6
2	Manure+lime	2.47	64.8	63.3	36.4	1.47	51.2	....	72.4	49.3
3	Manure	2.40	63.7	51.1	46.9	1.35	55.9	....	57.4	46.4
4	Manure+lime+rock phosphate	2.70	60.8	66.1	42.8	2.02	60.2	....	71.6	50.4
5	Manure+lime+acid phosphate	2.70	67.1	60.8	46.3	2.14	59.7	....	68.6	47.4
6	Manure+lime+complete commercial fertilizer	2.70	64.5	61.0	49.2	1.99	60.7	....	74.1	47.4
7	Check	1.65	60.0	51.9	36.9	1.35	40.0	....	43.6	34.4
8	Crop residues	2.05	62.5	55.0	42.8	1.40	46.2	....	47.4	37.8
9	Crop residues+lime	2.02	49.4	59.6	38.9	1.56	44.2	....	62.1	38.6
10	Crop residues+lime+rock phosphate	2.16	55.7	58.5	43.6	1.98	54.4	....	64.8	36.8
11	Crop residues+lime+acid phosphate	2.47	55.4	58.5	48.4	2.10	43.5	....	62.2	37.0
12	Crop residues+lime+complete commercial fertilizer	2.10	33.1	57.3	37.8	2.04	44.7	....	72.4	38.6
13	Check	1.80	45.7	41.1	36.0	1.51	36.1	....	45.3	30.9

1. Three and one-half tons lime, fall 1917.
2. Plots 10, 11, 12 and 13 on low ground, poor stand.
3. Plot 2 small ditch, abnormal yield.
4. Clover down badly on 5 and 6, and 11 and 12, only 85% could be cut.
5. Season dry.
6. Field was replanted and corn did not mature.
7. Plot 2 is high in fertility and poorly drained which resulted in high yield due to dry season.
8. Hot winds and dry weather damaged corn.

greater effect on the corn in 1922 and in 1923 than did the acid phosphate but in other cases it showed less value.

From the results secured on the Springville field, it is apparent that the application of manure is of great value on the Carrington silt loam and liberal applications of this material should be made. The type is acid in reaction. The use of lime is very desirable therefore, for the best growth of legumes, and beneficial effects will also be secured from the use of lime on other general farm crops. Applications of a phosphate fertilizer are to be recommended. Whether acid phosphate or rock phosphate should be employed cannot be definitely stated at the present time. It does not seem probable that a complete commercial fertilizer would be as desirable for use on this soil as acid phosphate, inasmuch as the latter material or the rock phospate seems to give quite as large increases in crop yields.

THE JESUP FIELD

The results secured in the field experiment on the Carrington loam, in Blackhawk County on the Jesup Field, Series II are given in table XVI. The beneficial effect of manure on this type is evidenced by the increased crop yields secured in practically all seasons. In some cases very large gains were noted from the applications of manure. This was true with the clover in 1919, the clover and timothy in 1920, the corn in 1921, 1922, and 1926. The application of lime with the manure proved of value in practically all seasons. In many cases very considerable increases in the yields of the crops were secured. The oats in

TABLE XV. FIELD EXPERIMENT, CARRINGTON SILT LOAM, LINN COUNTY SPRINGVILLE FIELD, SERIES II

Plot No.	Treatment	(1) 1919 Corn bu. per A.	(2) 1920 Oats bu. per A.	1921 Clover tons per A.	1922 Corn bu. per A.	(3) 1923 Corn bu. per A.	(4) 1924 Oats bu. per A.	(5) 1925 Clover tons per A.	(6) 1926 Corn bu. per A.
1	Check	61.1	41.1	1.16	62.6	32.0	....	0.87	40.0
2	Manure	66.0	46.8	1.42	76.0	40.0	....	0.90	41.0
3	Manure+lime	66.2	48.8	1.86	82.8	46.6	....	1.30	40.0
4	Manure+lime+rock phosphate	66.5	49.6	2.29	84.3	46.8	....	1.48	48.0
5	Manure+lime+acid phosphate	59.7	50.8	2.56	78.0	44.4	....	1.30	40.5
6	Manure+lime+complete commercial fertilizer	64.2	43.4	2.50	79.1	47.4	....	1.39	41.0
7	Check	57.1	47.6	1.51	62.9	33.5	....	0.95	36.8
8	Crop residues	56.9	47.6	1.17	61.7	36.2	....	0.78	37.8
9	Crop residues+lime	53.1	58.9	1.27	63.4	35.6	....	1.13	50.6
10	Crop residues+lime+ rock phosphate	61.4	63.7	2.31	60.6	34.9	....	1.15	44.8
11	Crop residues+lime+ acid phosphate	62.9	70.6	2.34	59.1	38.1	....	1.41	44.2
12	Crop residues+lime+ complete commercial fertilizer	60.0	50.2	2.25	74.7	44.9	....	1.35	44.2
13	Check	...	55.6	1.35	64.8	40.0	....	0.43	41.0

1. Plot 13 cut by mistake.
2. Wet spring reduced crop on manured plots, 4 tons lime, September.
3. Poor drainage made series weedy in spots.
4. No results taken.
5. No fertilizer applications made since spring of 1923, carried as a residual series.
6. Hot winds and dry weather damaged corn.

1918, the clover and timothy in 1920, the oats in 1923 and the clover in 1924 showed pronounced effects from the addition of the lime.

The application of rock phosphate with the manure and lime increased the crop yields in several seasons, altho in general no large effects were secured. Only in case of the corn in 1926 was there any large increase from the rock phosphate. In most seasons the gains were small, and in one or two seasons no increases at all were secured. The acid phosphate with the manure and lime had a larger effect than the rock phosphate in one or two cases as, for example, on the clover in 1919 and 1924. In most seasons, small differences between the effects of the two phosphates were noted. The complete commercial fertilizer increased the crop yields slightly more than did the acid phosphate in most seasons. In general, however, the differences were not very great and in one or two cases the complete commercial fertilizer showed less effect than the phosphates.

The crop residues had little effect on the crops grown in most seasons. In one or two cases increases were secured as, for example, on the clover in 1924. Lime with the crop residues increased the crop yields only in one or two seasons. The rock phosphate with the crop residues and lime brought about pronounced increases in the yields of crops in several cases, but in two instances no effects were noted. The acid phosphate with the crop residues and lime had a greater effect than the rock phosphate in most seasons. The differences in favor of the acid phosphate in some cases were quite pronounced as, for example, on the clover and timothy in 1920 and on the clover in 1924. The complete commercial fertilizer with the crop residues and lime showed a larger effect on the crops grown in practically every season. In some cases very considerable increases were secured.

From these results it is apparent that the liberal addition of manure to this soil is very desirable for the best growth of general farm crops. The type is

acid in reaction and the application of lime is very necessary if the best crops of legumes are to be secured. Lime also often brings about large increases in the yields of other general farm crops. The addition of a phosphate fertilizer is certainly very desirable on this soil, and in many cases large increases in crop yields are secured from the application. Whether acid phosphate or rock phosphate should be employed, has not been definitely determined. The use of a complete commercial fertilizer does not seem to be as desirable as the use of a phosphate.

THE WAVERLY FIELD

The data secured from the field experiment on the Carrington loam on the Waverly Field No. II, Series I, in Bremer County are given in table XVII. The beneficial influence of manure on this soil is shown by the increased crop yields secured in practically every season. In some cases very large gains were noted, as, for instance, on the clover in 1919. Lime with the manure brought about increased crop yields in practically all seasons. The effect was particularly evidenced on the oats in 1921 and 1925. The yield on plot 3 in 1919 was evidently abnormal.

The rock phosphate with the manure and lime increased the crop yields to a very pronounced extent in some seasons but in one or two cases showed no beneficial effect. The clover in 1919 was increased to a large extent and this was true also of the oats in 1925. The acid phosphate showed a greater effect than the rock phosphate in most seasons. The differences, however, were generally not

TABLE XVI. FIELD EXPERIMENT, CARRINGTON LOAM, BLACK HAWK COUNTY JESUP FIELD, SERIES II

Plot No.	Treatment	(1) 1918 Oats bu. per A.	1919 Clover tons per A.	(2) 1920 Clover and timothy tons per A.	1921 Corn bu. per A.	1922 Corn bu. per A.	(3) 1923 Oats bu. per A.	(4) 1924 Clover tons per A.	(5) 1925 Clover tons per A.	(6) 1920 Corn bu. per A.
1	Check	71.9	1.17	0.50	58.7	51.4	31.7	0.92	....	47.2
2	Manure	71.6	2.08	0.85	72.8	65.6	29.4	1.06	....	60.5
3	Manure+lime	83.1	1.92	1.20	77.6	71.1	37.3	1.26	....	60.0
4	Manure+lime+rock phosphate	81.8	1.86	1.15	78.1	73.4	41.8	1.29	....	72.5
5	Manure+lime+acid phosphate	76.1	2.22	1.12	75.5	73.4	45.3	1.65	....	73.3
6	Manure+lime+complete commercial fertilizer	77.2	2.80	1.25	78.7	77.6	44.2	1.60	....	65.3
7	Check	60.8	1.38	0.47	54.0	53.7	34.0	0.58	....	34.1
8	Crop residues	64.0	1.36	0.52	56.5	56.0	38.3	0.88	....	...
9	Crop residues+lime	64.9	1.15	0.42	46.4	52.0	36.3	1.15	....	...
10	Crop residues+lime+ rock phosphate	63.6	1.53	0.42	60.8	60.8	38.7	1.23	....	...
11	Crop residues+lime+ acid phosphate	62.5	1.53	0.60	67.6	62.6	38.3	1.62	....	...
12	Crop residues+lime+ complete commercial fertilizer	75.7	1.77	0.70	72.8	70.2	38.3	1.67	....	...
13	Check	67.8	1.20	0.65	60.2	55.4	34.0	1.18	....	...

1. Three and one-half tons lime applied.
2. Plots 9 and 10 in swale and poorly drained.
3. Oats thin, dry season.
4. Plot 7 poor due to poor drainage, plot 13 high due to old yard location.
5. Plots were pastured.
6. Crop residue plots were left in pasture and not plowed.

very large. In one case the acid phosphate showed less effect than the rock phosphate. The complete commercial fertilizer had a greater influence than the acid phosphate in one or two cases but in general showed a very similar effect to that brought about by the acid phosphate. Very large increases were noted, however, in 1925, from the complete commercial fertilizer.

The crop residues showed very little effect on the various crops grown. Lime with the residues increased the crop yields in all cases and in some instances very large gains were noted, particularly on the clover in 1919 and 1922. Large effects were also shown on the oats in 1921 and 1925. The rock phosphate with the crop residues and lime increased the crop yields to a considerable extent in practically every case. The largest influence was noted on the clover crops and on the oats in 1925. The acid phosphate with the crop residues and lime had a larger effect than the rock phosphate in practically every season. In some seasons the gain was very pronounced as, for example, on the clover in 1919 and 1922. In other cases the differences were not large. The complete commercial fertilizer with the crop residues and lime had very much the same effect as did the acid phosphate, showing a slightly greater influence in some cases and a smaller in others.

The results secured on the Carrington loam on the Waverly Field No. II, Series II, in Bremer County, are given in table XVIII. Here again the beneficial influence of manure on this soil is evidenced by the great increases in crop yields secured in practically every season. The clover in 1920 and 1921 and the corn in

TABLE XVII. FIELD EXPERIMENT, CARRINGTON LOAM, BREMER COUNTY WAVERLY FIELD, NO. 2, SERIES I

Plot No.	Treatment	(1) 1918 Corn bu. per A.	1919 Clover tons per A.	(2) 1920 Corn bu. per A.	(3) 1921 Oats bu. per A.	(4) 1922 Clover tons per A.	(5) 1923 Corn bu. per A.	(6) 1924 Corn bu. per A.	(7) 1925 Oats bu. per A.	(8) 1926 clover tons per A.
1	Check	42.8	1.50	47.8	25.7	2.22	....	11.0	...	....
2	Manure	61.0	1.75	56.5	34.3	2.20	....	24.7	63.9	....
3	Manure+lime	64.9	1.10	57.5	50.6	2.32	....	30.4	77.7	....
4	Manure+lime+rock phosphate	65.5	2.60	58.0	40.3	2.10	....	34.3	87.8	....
5	Manure+lime+complete commercial fertilizer	72.1	2.35	44.0	35.7	2.78	....	42.1	103.3	....
6	Manure+lime+acid phosphate	67.2	2.85	47.0	42.0	2.90	....	38.2	89.3	....
7	Check	55.1	1.55	36.6	30.6	1.76	....	19.2	59.9	....
8	Crop residues	49.6	1.05	39.6	20.3	1.24	....	18.8	51.7	....
9	Crop residues+lime	66.2	1.50	40.8	30.4	1.84	....	20.3	62.1	....
10	Crop residues+lime+rock phosphate	70.0	1.75	41.6	40.6	2.16	....	20.5	85.3	....
11	Crop residues+lime+acid phosphate	88.2	2.55	43.3	38.4	2.70	....	23.1	86.9	....
12	Crop residues+lime+complete commercial fertilizer	88.6	2.10	45.8	46.0	2.70	....	22.4	86.5	....
13	Check	79.7	1.55	35.1	26.7	1.48	....	16.3	53.4	....

1. Six tons lime, fall 1917.
2. Soybeans planted in corn, both crops poor. Wet spring injured plots in center series. Plots 5 and 6 and crop residue plots weedy.
3. Plot 3 too high, many morning glory vines on plot.
4. Stand uneven on 2 and 4.
5. No crop yields secured owing to drought.
6. Crop damaged by frost—phosphate plots showed more maturity.
7. Barley seeded by mistake on plot 1. Unable to account for high yield on plot 5.
8. Field pastured—no results taken.

1922 and 1923, showed the largest influence from the use of manure. The application of lime with the manure brought about distinct gains in crop yields in every season. In some cases the gains were very large, for for example on the clover in 1920, 1921 and 1925, the corn in 1923, the oats in 1924 and the alfalfa in 1926.

The rock phosphate with the manure and lime had a beneficial effect on the crop yields in most seasons. The differences, however, were not very great and in some cases no gains were noted. The acid phosphate with the manure and lime increased the yields to a considerable extent in most seasons, the largest effect being noted on the clover and alfalfa, altho there was a large effect also on the oats in 1924. The complete commercial fertilizer showed a somewhat greater effect than the acid phosphate in some cases but in several instances did not bring about as large increases.

The crop residues showed little effect on the crop yields, small increases being noted only in one or two cases. Lime with the residues increased the crop yields in a very pronounced way, in some cases bringing about very large increases as, for instance, on the sweet clover in 1925. The rock phosphate with the crop residues and lime increased the yields in most cases, the differences being considerable in some instances, as for example on the clover crops and on the oats in 1924. The acid phosphate with the crop residues and lime showed a larger effect than the rock phosphate in one or two cases but the differences were not large and in general the two phosphates seemed to give about the same returns. The complete commercial fertilizer showed a larger effect than the acid phos-

TABLE XVIII. FIELD EXPERIMENT, CARRINGTON LOAM, BREMER COUNTY WAVERLY FIELD NO. 2, SERIES II

Plot No.	Treatment	(1) 1918 Corn bu. per A	1919 Oats bu. per A.	(2) 1920 Clover tons per A.	1921 Clover and timothy tons per A.	(3) 1922 Corn bu. per A.	(4) 1923 Corn bu. per A.	1924 Oats bu. per A.	(5) 1925 Sweet clover tons per A.	(6) 1926 Alfalfa tons per A.
1	Check	38.5	39.8	0.47	1.03	39.4	25.0	42.8	0.39	...
2	Manure	54.0	49.3	0.67	1.30	55.7	40.2	49.7	0.45	0.76
3	Manure+lime	56.8	61.9	1.36	1.87	62.3	57.0	66.4	2.66	1.28
4	Manure+lime+rock phosphate	57.2	46.4	1.66	1.98	63.1	62.0	64.9	2.72	1.61
5	Manure+lime+acid phosphate	60.5	57.8	2.05	2.19	64.0	60.7	75.8	3.03	1.65
6	Manure+lime+complete commercial fertilizer	61.3	61.9	1.99	2.47	62.9	63.0	65.3	3.03	1.35
7	Check	48.7	35.4	0.84	1.17	45.7	34.2	42.5	0.62	0.67
8	Crop residues	46.4	39.4	0.67	1.09	41.4	34.0	48.3	0.62	0.69
9	Crop residues+lime	50.0	48.3	0.87	1.26	50.6	45.2	55.5	2.93	1.10
10	Crop residues+lime+rock phosphate	56.7	40.8	1.14	1.44	52.0	46.5	74.7	3.02	1.11
11	Crop residues+lime+acid phosphate	48.7	47.3	1.11	1.63	51.4	47.5	70.9	3.02	1.36
12	Crop residues+lime+complete commercial fertilizer	42.7	53.5	1.32	2.10	60.8	50.7	51.2	2.96	1.31
13	Check	33.4	32.9	0.33	0.87	34.8	43.2	37.8	0.45	0.69

1. Six tons lime, fall 1917. Heavy rains washed 11, 12 and 13 badly.
2. Plots 1 and 2 poorer in fertility than other plots.
3. Dry season.
4. Plot 13 high probably due to manure application made thru error.
5. Biennial white sweet clover.
6. Grasshoppers injured plot 1 and the west side of all plots.

phate in some cases, particularly on the clover and timothy in 1921 but in other instances there were smaller effects from the complete fertilizer.

These results as a whole serve to confirm the conclusions drawn from the experiment on the Carrington loam from Black Hawk County. Liberal applications of manure are strongly to be recommended and large crop increases will follow its use. The soil is acid in reaction and the addition of lime is very desirable in order to secure the best growth of general farm crops, and particularly to obtain the largest yields of legumes. The application of a phosphate fertilizer seems to be of particular value on this soil. Acid phosphate and rock phosphate both bring about large increases in the yields of general farm crops. The complete commercial fertilizer cannot be recommended for general use on this soil as the one of the phosphate fertilizers may probably be employed with quite as large an effect on the yields of general farm crops.

THE EVERLY FIELD

The results secured in the field experiments on the O'Neill loam in Clay County, on the Everly Field, Series I, are given in table XIX. The application of manure to this soil type is apparently of very large value. Increases in crop yields are secured in practically every season. In some cases very large gains are noted as, for example, on the clover in 1921, on the corn in 1922, and on the oats in 1924. Lime with the manure is of value on this soil and increases in crop yields quite generally follow its application. The effect of the lime was shown not only on the legume crops, but also on the other crops grown in the rotation. Large increases were secured in many seasons in the corn and oats.

TABLE XIX. FIELD EXPERIMENT, O'NEILL LOAM, CLAY COUNTY EVERLY FIELD, SERIES I

Plot No.	Treatment	(1) 1918 Corn bu. per A.	1919 Corn bu. per A.	(2) 1920 Oats bu. per A.	(3) 1921 Clover tons per A.	(4) 1922 Corn bu. per A.	(5) 1923 Corn bu. per A.	1924 Oats bu. per A.	(6) 1925 Clover tons per A.	1926 Corn bu. per A.
1	Check	47.7	37.1	23.3	1.80	41.2	37.2	47.9	0.40	51.5
2	Manure	56.2	34.1	27.5	2.35	51.5	37.0	58.8	0.48	59.3
3	Manure+lime	56.4	38.0	28.9	2.60	53.1	42.3	66.7	0.47	65.4
4	Manure+lime+rock phosphate	56.0	40.3	33.6	2.94	53.3	41.7	66.1	0.57	62.7
5	Manure+lime+acid phosphate	59.2	39.0	32.6	3.28	54.7	39.2	71.5	0.65	62.4
6	Manure+lime+complete commercial fertilizer	55.4	40.9	30.9	2.97	55.4	38.3	69.3	0.64	62.7
7	Check	46.6	37.1	24.1	1.80	44.6	35.8	44.6	0.40	54.9
8	Crop residues	51.4	36.4	24.9	2.00	45.6	36.4	49.7	0.43	52.8
9	Crop residues+lime	54.1	37.0	24.4	2.22	44.5	38.7	64.8	0.36	56.3
10	Crop residues+lime+rock phosphate	57.0	37.3	28.2	3.20	51.5	38.8	56.2	0.41	57.7
11	Crop residues+lime+acid phosphate	56.2	35.1	30.6	3.13	51.9	41.3	62.1	0.56	62.7
12	Crop residues+lime+complete commercial fertilizer	57.6	37.9	26.8	3.00	51.7	37.3	54.1	0.41	60.8
13	Check	47.2	32.1	23.1	1.87	40.9	33.3	37.8	0.41	50.3

1. Three tons lime, fall 1917.
2. Poor stand.
3. First cutting only.
4. Dry summer reduced yield.
5. Dry summer reduced yield.
6. Very small crop due to dry weather.

The rock phosphate, with the manure and lime, increased the crop yields in several seasons. In general, no large effects were noted, however, except on the clover in 1921. The acid phosphate, with the manure and lime showed a larger effect on the crop yields in several seasons. The beneficial influence of the acid phosphate was noted particularly on the clover in 1921 and 1925 and on the oats in 1924. In the other seasons, the differences between the effects of the two phosphates were not very pronounced. The complete commercial fertilizer with the manure and lime had about the same influence on the crop yields as did the phosphates. In one or two cases slightly greater yields were secured, while in other instances the yields were somewhat smaller. In no case, however, were there any large differences.

The crop residues showed little effect on the crops grown in most seasons. Lime, with the crop residues, brought about increases in the yields in practically all cases. In some seasons very large effects were noted as, for example, on the clover in 1921 and on the oats in 1924. The rock phosphate, with the crop residues and lime, increased the crop yields in practically all cases. In several seasons the increases were not very large, but in one or two cases, considerable gains were noted as on the clover in 1921. The acid phosphate with the crop residues and lime showed about the same effects on the crop yields as did the rock phosphate in many seasons. In one or two cases, larger increases were secured from the acid phosphate, but in general the differences were not very pronounced. The complete commercial fertilizer with the crop residues and lime, showed no greater effects on the crop yields than did the acid phosphate. In fact, in most instances slightly smaller crop yields were secured with the complete fertilizer.

The liberal application of manure to this soil is particularly to be recommended, inasmuch as the type is characterized by a sandy to gravelly subsoil and, hence, it tends to be droughty. The use of manure increases its water-holding power and therefore cuts down the injurious effects which are often evidenced on the crops grown on the type in dry seasons. The soil is acid in reaction and will respond to the addition of lime. The application of a phosphate fertilizer is of considerable value on this soil. In some cases the acid phosphate seemed preferable, while in other instances the rock phosphate was quite as good. The use of a complete commercial fertilizer cannot be recommended generally on this soil, inasmuch as acid phosphate or rock phosphate seem to bring about as large crop increases.

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

The laboratory, greenhouse and field experiments which have been discussed earlier in this report have given certain definite indications of the needs of some of the more important soils in this county. In most cases, therefore, recommendations may be made for the best treatments for the various individual soil types. The field tests, which have been discussed, have been carried on in other counties but the soil types are the same as those occurring extensively in Floyd County, and, hence, the results may be considered to indicate quite definitely the effects of the same fertilizer treatments in this area.

A field experiment has been located recently in Floyd County but the data secured in this test have not been secured over a long enough period of years to be of value, hence the results from this field are not included.

It is definitely understood that the recommendations regarding treatment of the various soils of the county are based, not only upon the experiments which have been discussed, but also upon the experience of many farmers. Only those suggestions which have been shown to be of considerable value by practical experience and by experiments are given. Any of the recommendations made can be put into effect on any farm.

In several cases it has been suggested that tests be carried out on individual farms. It should be noted that many farmers are carrying out tests on their own farms at the present time, and they are securing results which are of considerable value to themselves and to their neighbors who may be located on the same soil types. The Soils Section of the Iowa Agricultural Experiment Station is ready to aid farmers who may wish to carry out tests on their own soils, and will offer suggestions and such aid as is possible to all who may be interested.

LIMING

With the exception of the Lamoure silty clay loam on the bottomland, the soils of Floyd County are all acid in reaction in the surface soils, and, hence, they are in need of lime. In practically all of the types, the soils are not only acid in reaction at the surface, but the acidity is evident thruout the lower soil layers. Only in the case of the Dodgeville silt loam is there no acidity in the subsoil, hence the need of lime on the soils of the county is particularly evident, not only by the analyses of the surface soils, but by the tests made of the subsurface soils and subsoils.

In the table given earlier in this report, the limestone requirements of the various soil types are indicated. These figures, however, should be considered only indicative of the lime needs of the individual soils. Soils vary widely in acidity or lime requirement and the needs for lime may be quite different in soils of the same type under different conditions or even in soils of the same type in adjacent fields. It is always necessary, therefore, that the soil in any field be tested for acidity before an application of lime is made. In this way the proper amount may be employed and the best results secured. Farmers may test their own soils for lime needs but it will generally be much more satisfactory if they will send a small sample to the Soils Section of the Iowa Agricultural Experiment Station and have it tested free of charge.

The experimental work with lime has shown quite definitely the beneficial effects on crop yields resulting from the application of this material when the soil is acid. Large crop increases are secured from the lime in practically all cases. Not only are the leguminous crops grown in the rotation benefited to a considerable extent, but the yields of other general farm crops frequently are very materially increased when lime is applied. The experiences of many farmers with lime confirm the conclusions drawn from the greenhouse and field experiments. Definite indications are secured by practically all of the farmers who have applied lime to their acid soils, of the value from the use of this material.

Further information regarding the use of lime on soils, the losses by leaching and other points connected with liming are given in the Extension Bulletin, No. 105, of the Iowa Agricultural Extension Service.

MANURING

Many of the soil types in Floyd County seem to be very well supplied with organic matter. Their color is dark and in many cases even black. Some of the minor types, however, are rather light in color and in these soils, the supply of organic matter is low or deficient. This condition occurs particularly on some of the sandy soils. On all the types in the county, however, regular applications of fertilizing material supplying organic matter are necessary if the content of this constituent is to be kept up. On the lighter colored, coarser-textured soils, the supply of organic matter needs to be increased at the present time if the yields of general farm crops are to be most satisfactory. All the upland types, with the exception of the Clyde and Floyd soils, are not any too well supplied with organic matter. In some cases the content is low as, for example, in the Lindley silt loam, the Dickinson fine sandy loam and the Roseville silt loam. In other cases the supply is better, but still the soils are not rich in organic matter. This is true on some of the Carrington, Dickinson and Dodgeville soils, and is particularly true of the Clinton silt loam. On the terraces, some of the Buckner, Bremer and Waukesha soils are fairly well supplied with organic matter, but the O'Neill soils and some of the sandier Buckner types are low in organic matter. Even on those types which are better supplied at the present time such as the Clyde and the Floyd soils on the upland, and the Wabash and Lamoure soils on the bottoms, the application of organic matter must be made at regular intervals if the supply of this constituent is to be kept up.

Farm manure is the most valuable fertilizing material which can be used on the soils of this county. Its application will be particularly valuable on those types which are light in color and coarse in texture and lacking in organic matter. But large increases in crop yields may also be secured from the use of farm manure on soils which are heavier in texture and darker in color, and apparently better supplied with organic matter. Larger applications of the manure may be made on those soils which are apparently more in need of organic matter, while the applications made to the heavier, darker colored soils may be smaller.

The experimental work which has been carried out in the greenhouse and in the field on the soil types in this county have indicated very definite beneficial effects from application of farm manure to these soils. Thus, it has been found that the Carrington silt loam, the Clyde silt loam, the Carrington loam, the O'Neill loam and the Clinton silt loam will respond very profitably to applications of farm manure. Large beneficial effects from the use of this material will undoubtedly be secured on the other soil types occurring in this county.

In livestock farming the proper application and preservation of the manure produced will supply a very valuable fertilizing material, which will aid materially in keeping up the supply of organic matter in the soils. In many cases, however, the amount of manure produced is inadequate for all the soils on the

farm. In grain farming little or no manure is produced, and hence some other source of organic matter must be sought. In both these cases the turning under of leguminous crops as green manures is a very desirable practice. Large amounts of organic matter may be added to the soil in this way, but it is also possible to supply considerable amounts of nitrogen if the legumes are well inoculated as they should be when properly grown. There are undoubtedly cases in Floyd County where the turning under of leguminous crops as green manures would be very desirable and would lead to profitable increases in crop yields. This would undoubtedly be true on the lighter colored, coarser textured soils where increasing the content of organic matter is more necessary and where the supply of nitrogen is also low. Care should always be exercised, however, when green manuring is practiced as undesirable results may occur if the conditions in the soil do not permit of the best decomposition of the green material.

In addition to the proper use of farm manure, and the turning under of green manure crops, the proper utilization of all the crop residues produced on the farm will aid considerably in keeping up the supply of organic matter in the soil. There is also some addition of plant food constituents. On the livestock farm, they may be used for feed or bedding and returned to the land with the manure. On the grain farm, they may be stored and allowed to decompose partially before they are applied or they may be applied directly to the land.

THE USE OF COMMERCIAL FERTILIZERS

It is apparent from the analyses that have been given earlier in this report, that phosphorus is deficient in the soils of this county, or at least the supply is so low that the amount of available phosphorus which is provided for the growth of crops will certainly be inadequate for the best crop yields. It is certain that phosphorus fertilizers will be needed in the very near future, and it seems quite possible that they may have a definite value when applied at the present time.

The experimental work in the greenhouse and in the fields on some of the same soil types which occur in Floyd County has indicated the value from the application of phosphate fertilizers to some of these soils. The tests on the Carrington silt loam, the Carrington loam and the O'Neill loam as carried out in the field and the greenhouse tests on the Carrington silt loam, the Clyde silt loam, the Carrington loam and the Clinton silt loam have all indicated the beneficial effects of applications of rock phosphate or acid phosphate. In some cases the acid phosphate has seemed preferable while in other cases the rock phosphate has given quite as satisfactory results.

The rock phosphate is applied at the rate of one ton per acre once in the four-year rotation according to the usual farm practice. In recent years the application has been made in the field experiments at the rate of one-half ton once in the four-year rotation. The acid phosphate is applied at the rate of 150 pounds to 200 pounds annually or at least three times in a four-year rotation. The acid phosphate is more expensive than the rock phosphate but the applications are smaller. This material supplies the element phosphorus in the form which is immediately available for plant use, while in the rock phosphate the phosphorus must be changed into the available form before it can be utilized. To determine accurately the relative value of these two fertilizing materials, the tests must be carried out over a number of years, and the value of the crop increases over the actual cost of the applications must be determined.

The data thus far available have not indicated definitely whether acid phosphate or rock phosphate will be more profitable for use thruout this county. It is recommended, therefore, that farmers test both phosphates and thus determine for their particular conditions whether the soil will respond to the use of a phosphate fertilizer and which material will be more desirable for use. Simple tests may be carried out on any farm using these two phosphates. Directions which may be followed in carrying out such tests are given in Circular 97 of the Iowa Agricultural Experiment Station.

The supply of nitrogen seems to be quite adequate in many of the soils in Floyd County, but in one or two cases the content of this element is low. Wherever the supply is inadequate, additions of nitrogen-containing fertilizers are very necessary, but in all cases such fertilizers should be supplied at regular intervals, if the content of nitrogen is to be kept up in these soils. There is a regular removal of nitrogen from the land by the growth of crops and by leaching in the drainage water. Additions must be made or the nitrogen supply will very quickly become inadequate for the best crop yields. On the light colored, coarse textured soils, additions of nitrogenous fertilizers are necessary at the present time, but some nitrogen-containing fertilizers must be utilized on the heavier textured soils, which are darker in color or the supply will soon be inadequate.

The use of leguminous crops as green manures is generally conceded to be the cheapest and best means of supplying nitrogen to the land. When inoculated the legumes take a large part of their nitrogen from the atmosphere and then when the crops are turned under in the soil as green manures, there is a corresponding increase in the nitrogen content of the soil. This practice may be very desirable in many cases in Floyd County. There is a double value from this practice, in that the organic matter as well as the nitrogen content of the soil is built up.

The proper application and preservation of all the manure produced on the livestock farm is a very important means of returning to the land some of the nitrogen removed by the crops grown. On the grain farm, very little manure is produced and here leguminous green manures must be depended upon as a source of nitrogen. On the livestock farm, however, farm manure may play a large part in building up and keeping up the content of nitrogen in the land. This can only be accomplished if the farm manure is properly preserved and applied. Crop residues also supply nitrogen to the land and hence the proper utilization of these materials is very desirable as an aid in maintaining the nitrogen content of the soil.

The use of commercial nitrogenous fertilizers is probably unnecessary on the soils of Floyd County at the present time, inasmuch as the supply of nitrogen may be increased and maintained in these soils thru the proper utilization of leguminous crops as green manures and by the proper preservation and application to the land of all the farm manure produced and of all the crop residues.

Previous analyses have shown that the soils of Floyd County contain considerable amounts of potassium and it does not seem likely that potassium fertilizers will be of value when applied to these soils. The amount present in the soils is so large that there should be a sufficient supply available for a large number of crops, provided the potassium is changed into an available form as rapidly as is necessary. The maintenance of the proper conditions in the soil for the best growth of crops will aid in making the potassium available. Thus the proper cultivation and drainage of the land, remedying any acid conditions in the soil, the application of farm manure and green manures and the use of various fertilizing materials will aid in the production of available potassium in the soils. It is possible that in some cases potassium fertilizers may be desirable for use as top dressings and that in other instances small amounts of potassium fertilizer might yield profitable results. Tests of these fertilizing materials should always be carried out on a small scale, however, before an extensive application is made.

In the experimental work discussed earlier, a complete commercial fertilizer was tested in comparison with rock phosphate and acid phosphate. Increased crop yields were usually secured from the use of this complete fertilizer, but in most instances the increases from the phosphate fertilizers proved quite as large, and hence, the use of the more expensive fertilizing material would be economically undesirable. The complete commercial fertilizers are much more expensive than the phosphate fertilizers and hence if they are to prove as profitable for use, they must bring about very much larger increases than those occasioned by the phosphates.

It seems reasonable to believe that applications of acid phosphate or rock phosphate would be preferable because of the fact that the soils are not strikingly deficient in nitrogen and any lack of this element may be more economically supplied by the proper use of leguminous crops as green manures, than by using commercial nitrogenous fertilizers. The content of total potassium is high, and there is not apt to be a lack of this element in the soil, hence, the nitrogen and potassium contained in the complete commercial fertilizer are not of very large value from the standpoint of crop increases. The phosphorus content is the part of the complete fertilizer which is of particular value and it would, therefore, be cheaper to use a phosphate fertilizer.

The general use of complete commercial fertilizers on these soils cannot be recommended at the present time. There are probably cases where a complete brand would prove profitable. Farmers who are interested are urged to test any complete fertilizer which they may desire in comparison with acid phosphate. If they secure profitable returns from the use of the fertilizer, there is no objection to its application. It is entirely a question of the profit secured from the treatment.

DRAINAGE

It has been noted previously in this report that while the natural drainage system in the county is quite adequate in some sections, there are areas in which it is imperfectly developed. Along the smaller creeks and streams, the valleys are shallow and the surrounding country is gently rolling to flat. Here and at the

heads of drainageways, the level topography of the land and the heavy subsoil conditions are responsible for inadequate drainage. The installation of tile is very desirable in many of these areas and in general it may be said that in all parts of the county where drainage conditions are not entirely satisfactory, tiling would be of distinct value.

The drainage map that has been given earlier in this report shows definitely that there are areas in the county where natural drainage is inadequate. Some of the individual soils types show definite need of drainage as for example the Clyde silt loam and the Clyde silty clay loam on the drift uplands. There are also areas in the Carrington silt loam where drainage is not sufficient. On the terraces the Bremer soils are particularly in need of drainage. All of the bottomland types are particularly in need of drainage. On the bottoms, the soils are subject to overflow and hence, good crop yields cannot be secured until they are protected from overflow and properly drained. When a soil is too wet, good crop yields will not be secured. The first treatment needed, therefore, on many of the soils in Floyd County is the installation of tile in order to bring about good drainage. No fertilizing treatment will be of any value if the soil is not properly drained. The expense involved may be considerable when tile is installed. Farmers may be certain, however, that the increased crop yields secured will more than pay for the cost of installation. Much data has been secured during past years showing the large increases brought about by proper drainage. In many cases it has been found that the installation of tile would mean the difference between crop failure and a satisfactory crop.

THE ROTATION OF CROPS

It has been demonstrated in many experiments that the continuous growing of any one crop very quickly reduces the fertility of the soil. Farmers who follow the practice year after year of growing the same crop on the same land, very soon begin to notice a gradual decrease in crop yields and eventually the yields will become so low as to be unprofitable. In spite of this fact and the general knowledge of it, the large money value of some crops frequently causes farmers to follow the very undesirable practice of continuous cropping.

It should be emphasized that the rotation of crops is a more profitable practice than continuous cropping in spite of the fact that the rotation may include crops which do not have as large a money value. Experiments have indicated that the profits secured where the rotation of crops is practiced are much greater than where continuous cropping is followed. This is due to the fact that under the rotation system the crop yields are not decreased as rapidly as when one crop is grown continuously. It has been shown further that the rotation of crops permits of the maintenance of the permanent fertility of the soil more readily.

No definite rotation experiments have been carried out in Floyd County and only general recommendations may be made in regard to the rotations which may be followed in this county. There are a number of good rotations which are being practiced in various parts of the state, and some of these may be suitable for use in Floyd County. From among the rotations listed below some one may

be chosen for use in this county, or to serve as a basis on which a rotation may be worked out for any individual farm conditions. It should be emphasized that the farmers of the county should see to it that a good rotation is adopted if they expect to keep up their crop yields and maintain the fertility of their soils.

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
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.

2. 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)

3. 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)

4. 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)

5. 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 sweet clover)
Third year—Sweet clover (The clover may be mixed clovers and used largely as pasture and green manure)
(This may be changed to a two-year rotation by plowing the sweet clover under the following spring for corn)

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

THE PREVENTION OF EROSION

Erosion is the carrying away of the surface soil by the free movement of water over the surface of the land, known as sheet erosion or the washing away of the soil with the formation of gullies, gulches or ravines.

Erosion occures to a considerable extent in many of the soil types in Floyd County. On the drift upland, the Lindley silt loam is particularly subject to erosion, but much washing sometimes takes place on the more rolling areas of Carrington silt loam, Carrington loam, Dodgeville silt loam and Roseville silt loam. The Clinton silt loam on the loessial upland is also frequently badly eroded. Washing sometimes occurs on the high terrace types, particularly the O'Neill and Waukesha soils, but the erosion on these terrace soils is not of great significance. Wherever these effects of erosion occur, some means of prevention and control of the destructive action should be adopted.

Various methods are followed for the control and prevention of erosion in Iowa. These methods differ somewhat depending upon the type of erosion. Erosion occurring due to "dead furrows" may be controlled by "plowing in," by "staking in," or by the use of earth dams.

Small gullies may be filled by the "staking in" operation, by the use of straw dams, earth dams, Christopher or Dickey dams, Adams dams, stone dams, rubbish dams, woven wire dams, concrete dams. They may be prevented from occurring by thoro drainage or by the use of sod strips. Large gullies are similarly filled or prevented from occurring. Erosion in bottomlands is prevented by straightening the streams, by tiling and by planting trees up the drainage channels. Hillside erosion is controlled by the use of organic matter, by growing cover crops, by contour discing, by terracing, by deep plowing and by the use of sod strips.*

INDIVIDUAL SOIL TYPES IN FLOYD COUNTY†‡

There are 23 soil types in Floyd County and these with the areas of meadow and muck and peat make a total of 25 individual areas. They are divided into four groups on the basis of their origin and location, known as drift soils, loess soils, terrace soils, and swamp and bottomland soils.

DRIFT SOILS

There are ten drift soil types in the county, classified in the Carrington, Clyde, Floyd, Lindley, Dodgeville, Dickinson and Roseville series. Together, they cover 83.7 percent of the total area of the county.

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*See Bulletin 183. Soil Erosion in Iowa. Iowa Agricultural Experiment Station and Extension Service Bulletins 93, 94, 95, 96. Agricultural Extension Service, Iowa State College.

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

‡In a few places the soils as mapped in Floyd County do not have the same name as those mapped just across the line in Mitchell County. For example some of the Shelby soils as mapped in Mitchell County join Dickinson soils in Floyd County. The Dickinson soils are identical with the Shelby soils in all respects, except that of a more sandy or gravelly subsoil. When Mitchell County was mapped, such soils were not separated from the Shelby, but since that time it has been concluded to do so and call them Dickinson soils. The same or a similar change has taken place with regard to the Waukesha soils. Those with sandy and gravelly subsoils are called O'Neill soils.

CARRINGTON SILT LOAM (83)

The Carrington silt loam is the most extensively developed individual soil type in the county, as well as the largest drift soil. It covers over half or 51.0 percent of the area. It is the predominant type on the upland in all parts. There are many large individual areas of the type cut by the various streams of the county, with their accompanying terrace and bottomland soils and in many places cut into small areas by the other upland types of the Carrington, Clyde, Dickinson, Floyd, Dodgeville, and the Roseville series. The largest individual areas of the type are found in the central townships, particularly in the south central portion of the county.

The surface soil of the Carrington silt loam is the dark brown silt loam, 10 to 14 inches in depth. The subsoil is a lighter brown to yellowish-brown silty clay loam, pasing at 20 to 26 inches into a yellowish-brown, faintly mottled with gray, and brownish-yellow, silty clay loam to silty clay. In the lower part of the three-foot section there is much coarse sand and gravel. In many places boulders occur. The subsoil of the type is characterized by the faint gray mottlings which occur quite commonly. In this characteristic the type differs from the typical Carrington which occurs in the counties to the west.

There are some variations from the typical soil in various parts of the county. In parts of sections 14 and 15 of Ulster Township and in sections 3, 4, 9, 10 and 11 of Union Township, the surface soil is much deeper ranging from 16 to 20 inches. Below this point the subsoil is a yellowish-brown heavy friable silt loam to silty clay loam, comparatively free from mottlings. East of the Cedar River in parts of sections 5 and 6, of Floyd Township and sections 7, 8, 9, 15 and 16 of Cedar Township, the soil differs from the typical in that the surface soil contains much fine sand and approaches a fine loam in texture. Here the subsoil is a mottled gray and yellowish-brown sandy clay with considerable gravel and some boulders. Similar areas are found in sections 26 and 27 in Pleasant Grove Township. Included with the type there are a few small areas of fine sandy loam which are not sufficiently large to warrant separation on the map.

In topography the Carrington silt loam ranges from gently rolling to strongly rolling. The greater part of it, however, varies from undulating to rolling, the slopes being long and even and the hill crests rounded. Along the Cedar, Little Cedar, and Shellrock Rivers there are narrow bands from a quarter of a mile to two miles in width where the relief is more pronounced. In general the drainage of the type is quite satisfactory, especially on the areas where the topography is more rolling. Where the topographic conditions are more nearly level, the drainage is sometimes inadequate and in many places the installation of tile would be of considerable value.

Practically all of the Carrington silt loam is suitable for farming. The area in forests is small including strips along some of the streams and groves which have been set out to protect the farms from winds from the north and west. The trees consist mostly of oak, elm, maple and ash with some evergreen. The chief crops grown include corn, oats, and hay, with some barley, alfalfa, wheat, rye, buckwheat and sorghum grown for home use. Some millet is produced, chiefly for feed. Corn yields from 35 to 60 bushels per acre, averaging around 37 bushels per acre. Oats yield from 28 to 55 bushels per acre. Some wheat is grown, yielding from 10 to 18 bushels per acre. Barley yields 15 to 30 bushels per acre and hay from one to one and one-half tons per acre. There are many variations from these average figures, and under the best conditions, the yields of these general farm crops are very high. Corn often gives yields of from 50 to 90 bushels per acre.

The crop yields on the Carrington silt loam are in the main quite satisfactory, but experiments and much farm experience have shown that considerable increases in yields may be secured thru proper soil treatment. Wherever the soil is improperly drained, the installation of tile is the first treatment necessary to secure the best growth of crops. The soil is acid in reaction and applications of lime are necessary for the best growth of legumes and will bring about large increases in the yields of other general farm crops. Applications of farm manure are valuable on this soil and crop yields are increased considerably thru the proper use of farm manure. The type will respond to applications of a phosphate fertilizer. Whether rock phosphate or acid phosphate should be employed generally on this soil cannot be definitely stated at the present time. The experiments which have been carried out have sometimes indicated a larger value for the acid phosphate while in other cases, the rock phosphate seems to have given quite as satisfactory results. It is recommended, therefore, that farmers test the value of both acid phosphate and rock phosphate on their own soils. Tests carried out on small areas using these materials will show whether or not the soil will respond in a profitable way to the application of a phosphate fertilizer, and will also show whether acid phosphate or rock phosphate will be more profitable for general use.

The application of a complete commercial fertilizer rather than acid phosphate cannot be recommended for this soil. The experiments comparing these two materials have indicated that the phosphate fertilizers will in general bring about more profitable returns, because the increases in crop yields are very much the same from the two materials and the greater cost of the complete commercial fertilizer would make the use of the phosphate more profitable economically.

CLYDE SILT LOAM (84)

The Clyde silt loam is the second largest soil type and the second most extensively developed drift soil. It covers 14.2 percent of the area. It occurs in small areas in all parts of the county, in association with the Carrington silt loam and the other upland types. Most of the areas of the type are small, the largest individual areas occurring in St. Charles Township, southeast of Oakwood and in Rock Grove and Cedar Townships. The soil occupies the low, broad, flat and depressed areas at the heads of the drainageways. In other parts of the county, it is found principally in narrow depressions in the upland where drainage is lacking or poorly defined.

The surface soil of the Clyde silt loam is a very dark brown to black silt loam, 10 to 12 inches in depth. The upper subsoil is a black silty clay loam changing at 18 to 20 inches into a gray silty clay loam to brown clay, mottled with dark gray and stained with iron. In some of the areas boulders occur on the surface and thru the soil section.

The type is usually quite uniform in color and texture. In some of the level

areas where it is associated with the Floyd silt loam there is a gradual change from the one type to the other, and the boundary lines are quite arbitrarily drawn. Within the type, there are included many small areas of the Clyde silty clay loam, which were too small to show separately on the map. Along some of the intermittent drainageways where the type has been mapped, there are very narrow bands of Wabash silt loam. These could not be shown on the map because of their very small extent.

The topography of the Clyde silt loam is level to flat or depressed and the natural drainage condition is poor. The larger part of the type is still in its native undrained condition.

Much of the Clyde silt loam is utilized for hay or pasture. The larger areas are used mainly for the production of wild hay. The smaller areas serve as pasture. On those areas where drainage is adequate general farm crops are grown, giving quite satisfactory yields. Corn does very well on well drained areas of the type. Oats are grown to some extent, but tend to lodge.

The chief need of this soil to make it more productive is thoro drainage. When drainage has been accomplished by the installation of tile or ditches, satisfactory yields of general farm crops may be secured. The type is naturally very fertile and will produce good crop yields. Experiments have shown, however, that it will respond to applications of certain fertilizing materials after drainage has been accomplished. While it is high in organic matter, and black in color the application of small amounts of farm manure has been found to be of value. The type is acid in reaction and will respond to lime for the best growth of leguminous crops. The addition of a phosphate fertilizer is very desirable on this soil and tests of rock phosphate and acid phosphate are recommended.

FLOYD SILT LOAM (198)

The Floyd silt loam is the third largest soil type and the third most extensive drift soil. It covers 7.7 percent of the total area. This type is found developed in numerous areas. The largest areas occur north of Rudd, in the extreme northeast corner of the county, north of Colwell, and in the vicinity of Oakwood. Rather extensive areas of the type are found thru Rock Grove, Rudd, Ulster, and St. Charles Townships. Small areas occur in other parts.

The surface soil of the Floyd silt loam is a dark brown to almost black mellow silt loam, 16 to 18 inches in depth. The subsoil is a lighter brown to grayish-brown heavy silt loam, grading from 22 to 24 inches into a grayish-brown to gray silty clay loam, mottled with gray and brownish-yellow. The lower subsoil from 33 to 36 inches is a gritty, grayish-brown sandy loam, mottled with rusty brown and yellow.

In general the surface soil of the Floyd silt loam is uniform in both color and texture, but there are variations in some areas. In the more strongly undulating areas, the subsoil is very much the same as that of the Carrington, differing from it only in that the lower 6 or 8 inches of the soil section is a mottled grayish-brown, yellow and gray sandy clay loam to sandy clay. The areas where this subsoil condition occurs are small in extent except in sections 1, 11, 12, 13 and 14 of Pleasant Grove Township. In sections 20, 21, 28 and 29 of Niles Township, the soil is a brown to dark brown silt loam 8 to 10 inches in depth

underlaid to 14 to 18 inches by a gray to grayish-brown silt loam. The subsoil is a grayish-yellow or a yellowish-brown silty clay loam containing considerable sand below 30 inches. In the large area three miles north of Powerville, the surface soil is a black heavy silt loam to silty clay loam underlaid at from 18 to 22 inches by a gray silty clay loam, mottled in the lower depths with yellow and dark gray.

Included within the type are four areas which would have been separated as a different soil type had they been more extensively developed. One area is found in the eastern part of section 31 of Rudd Township. Two other small areas occur in the center of section 5, in Ulster Township. The fourth and largest occurs in section 34 of Union Township. In these areas the soil is a dark brown to black silt loam underlaid from 16 to 18 inches by a yellowish-brown to grayish-brown heavy silty clay mottled with gray, brownish-red, and yellow.

In topography the Floyd silt loam is level to flat or depressed. The drainage is poor and tiling is necesary to prepare the land for the best growth of cultivated crops.

Much of the type is utilized for the growth of wild hay and pasture, largely because it has not yet been properly drained. On a few areas there are trees consisting chiefly of willows and of such trees as are used for wind breaks around the farmsteads. On the cultivated areas where drainage is adequate, corn and hay are the most important crops. Some wheat, flax and buckwheat are sometimes grown.

On the better drained areas, the yields of general farm crops are very much the same as those secured on the Carrington silt loam. The treatments to which this soil will respond are likewise similar to those which bring about results on the Carrington silt loam. The type needs first of all to be thoroly drained if it is to be made most productive. It will respond to applications of farm manure and large increases in crop yields follow the application of this material. The soil is acid in reaction and will be benefited for the growth of legumes by the application of lime. The use of a phosphate fertilizer is very desirable on this soil and tests of acid phosphate and rock phosphate under individual farm conditions are recommended.

LINDLEY SILT LOAM (32)

The Lindley silt loam is the fourth largest drift soil, covering 3.1 percent of the total area. It occurs in a number of areas, some rather extensive in size. They are found along the principal drainage ways where the soils have developed under forest growth. The largest areas of the type are found along the west banks of the Little Cedar River, on the east bank of Cedar River north of Floyd, northeast of Charles City and on both sides of Flood Creek just west of Oakwood. There are a number of other smaller areas of the type.

The surface soil of the Lindley silt loam is a grayish-brown to gray silt loam to the depth of 8 to 12 inches. It contains considerable quantities of fine sand. The subsoil is a brownish-yellow to yellowish-brown heavy tough sandy clay, mottled with gray and brown and containing much gravel. Boulders occur in the soil and subsoil.

There are some variations from the typical soil in the different areas. The

surface soil in the area a few miles north of Floyd, is more silty and the subsoil is tougher and more compact. Here the surface soil is a gray to a light gray silt loam 10 to 12 inches in depth, underlaid by very compact tough gray silty clay loam to heavy silt loam, mottled with yellowish-brown and bright yellow. In some areas, the subsoil contains rock material from the original glacial till. In the areas where the type adjoins the Carrington silt loam the surface soil is a brownish-gray in color and the subsoil is more uniformly a yellowish-brown.

The typical topography of the Lindley silt loam is gently undulating to rolling. The drainage is generally adequate for crop production. The soil is subject to erosion due to the rolling topography and in the rougher sections considerable washing of the soil has occurred.

About 70 percent of the type has been cleared and brought under cultivation or utilized for pasture. The tree growth consists mostly of oak, elm, ash and hazel. On the cultivated areas, corn is the chief crop. Oats, barley, clover and timothy are also grown.

The yields of general farm crops may be increased considerably on this soil thru the adoption of proper methods of soil treatment. The type should be protected from erosion, if cultivated crops are to be grown as there may be considerable injury from the washing away of the surface soil, or from the formation of gullies. The type is low in organic matter and will respond to the application of farm manure. Liberal amounts of manure should be applied and in many cases the turning under of leguminous crops as green manures would also undoubtedly be valuable. The soil is acid in reaction and will respond to additions of lime. The application of a phosphate fertilizer is strongly recommended and tests of acid phosphate and rock phosphate should be carried out on individual farms to determine which phosphate will give the more profitable returns. Probably the acid phosphate will be more desirable for the first test on this soil because of the low organic matter content of the type.

DODGEVILLE SILT LOAM (204)

The Dodgeville silt loam is the fifth largest drift soil type, covering 2.7 percent of the total area. It ocurs in numerous areas in various parts of the county, chiefly, however, along the Cedar and Shellrock Rivers and the tributaries of the latter stream, Lime and Beaver Creeks and Ackley Run. The largest areas of the type are found in Rockford Township west of Rockford and in Floyd and Rudd Townships south and west of Devonia. There are a number of other small areas of the type, several of which are found in the southwestern townships.

The surface soil of the Dodgeville silt loam is a dark brown to very dark grayish-brown silt loam, extending to a depth of 8 to 14 inches. The subsoil is a brown or yellowish-brown heavy silt loam or silty clay loam, resting on limestone at depths of less than three feet.

In the southeastern part of the county there are some variations from the typical soil. Here the type is found in small isolated bodies, consisting of a dark colored silt loam and resting upon bed rock at rather shallow depths. In many places the rock apears at the surface. In other areas the dark colored surface soil has been removed and the grayish-brown or yellowish-brown underlying material is exposed. In the areas found west of Lime Creek and the Shellrock River, the type contains many areas of this light colored material at the surface. In some of the other areas of the type the soil varies from the typical, by consisting mainly of light colored materials and being very shallow in depth.

The Dodgeville silt loam varies in topography from undulating to strongly rolling.

The steeper, rougher areas of the type are unfit for cultivation and are left in grass and utilized for pasture. The only tree growth consists of windbreaks which have been set out to protect the farmsteads. The smoother areas of the soil are utilized largely for the production of general farm crops, such as corn, oats and hay.

The yields of general farm crops on the better portions of the type are fairly satisfactory. The soil will respond very profitably to applications of farm manure to build up the organic matter content. While it rests upon limestone, the surface soil is apt to be acid in reaction and additions of lime are necessary if leguminous crops are to be most successful. The application of a phosphate fertilizer is very desirable on this soil and tests of rock phosphate and acid phosphate are recommended.

CARRINGTON LOAM (1)

The Carrington loam is the sixth largest drift soil, covering about 2.0 percent of the total area. It is found in a number of areas varying widely in size but generally not very extensive. It is found along the various streams of the county, chiefly on the land sloping to the larger streams. There are a number of small areas, however, in the upland, at some distance from the stream courses. The largest bodies of the type are found on the east side of the Cedar River, north of Charles City and in the vicinity of Charles City, and south of the city. Other extensive areas of the type are found along the Shellrock River and some of its tributaries. A number of small areas of the Carrington loam occur in the southeastern townships on the uplands at considerable distance from the streams and intermittent drainageways.

The surface soil of the Carrington loam is a brown to dark brown mellow loam, 9 to 14 inches in depth and containing considerable amounts of coarse sand. The subsoil is a yellowish-brown heavy silt loam to silty clay loam, changing at 20 to 24 inches into a yellowish-brown gritty silty clay loam, faintly mottled with gray. At the lower depths the gray mottlings increase and at three feet the subsoil has a mottled gray and yellowish-brown color.

Where the soil occurs in association with the Dickinson fine sandy loam, there is a gradual change from one type to the other and the boundaries are rather arbitrarily placed. Included within the type there are areas of fine sandy loam and silt loam of the same series which are too small to separate out on the map.

In topography the Carrington loam is gently sloping to rolling or rough. Drainage is well established in all areas. The soil in many cases is subject to erosion, gullying occurring in some places and surface washing being common.

Practically all of the type is in cultivation or in pasture. The tree growth consists of oak and hazel brush, windbreaks of evergreens, maple, ash and elm.

Corn, oats and hay are the principal crops grown. Some rye, wheat, barley and sorghum are produced for home consumption. Corn yields from 32 to 50 bushels per acre, oats from 25 to 50 bushels per acre and hay from one to two tons per acre.

The yields of general farm crops are generally quite satisfactory on the Carrington loam but it has been found from experience and some experiments, that crop yields may be largely increased thru certain methods of soil treatment. The type will respond very profitably to applications of farm manure and liberal amounts of this material should be employed. The soil is acid in reaction and applications of lime have been found to increase the yields of general farm crops to a considerable extent. Leguminous crops are ordinarily benefited the most but in many cases very profitable increases in the yields of all general farm crops are secured. The application of a phosphate fertilizer has been found to be of value and both acid phosphate and rock phosphate have produced profitable increases on this soil. Farmers are urged to test both materials on their own soils so that they may determine which will be the more profitable to use under their particular conditions. The use of complete commercial fertilizers does not seem to be as desirable on this soil as the application of a phosphate fertilizer, inasmuch as the increases brought about in crop yields by the complete fertilizer are not sufficiently great to warrant the application of the more expensive material.

DICKINSON FINE SANDY LOAM (175)

The Dickinson fine sandy loam is the seventh largest drift soil, covering 1.6 percent of the total area. It occurs in numerous areas along the major streams. The largest development of the type is along the Cedar River north of Charles City. Rather extensive areas are found south of the city along the same river. Here, however, there are a number of areas which are smaller in extent. Several other areas, rather considerable in size, are found along the Shellrock River in the vicinity of Marble Rock and south to the county line. There are a number of areas in the north central part of the county east of Devonia, between the Litle Cedar and the Cedar Rivers.

The surface soil of the Dickinson fine sandy loam is a dark brown to very dark brown fine sandy loam, 15 to 18 inches in depth. The subsoil is a brownish-yellow or yellowish-brown fine sand.

In many places the surface soil approaches a loamy fine sand to fine sand, containing considerable organic matter. Some variations from the typical soil are found in the various areas of the type. In Section 15, in Niles Township, there are two areas where the surface soil is a light brown to grayish-brown fine loam to sandy loam 8 to 12 inches in depth. The subsoil here is a yellowish-brown sandy loam grading into a sticky sand and gravel. Included with the type there are a few areas where the soil has the texture of a loam. In some places the surface soil is a silt loam. These areas were too small to separate on the map.

In topography the Dickinson fine sandy loam varies from rolling to hillocky. It is found on knolls, low rounded hills and hillsides, along the larger streams and in knolls and knobs in other parts of the county. The drainage is good to excessive and crops are apt to suffer in periods of drouth.

Practically all of the type is in cultivation or utilized for pasture. On the cultivated areas general farm crops such as corn, oats and hay, are grown. In some places truck crops, watermelons, cantaloupes, potatoes and garden truck are produced.

The yields of crops on the Dickinson fine sandy loam are somewhat lower than those secured on the types which occur adjacent to it. Large increases in the yields of crops may be secured thru proper treatment. The soil is low in organic matter and will respond to applications of farm manure or the turning under of leguminous green manure crops. This will build up the supply of organic matter and nitrogen in the soil and also protect the crop from injury during periods of drouth. The type is acid in reaction and lime should be applied if legumes are to be grown. Increases in the yields of other farm crops will follow the application of lime to this type. The use of a phosphate fertilizer is very desirable on this soil for general farm crops. Acid phosphate will probably be the most desirable for use at the present time, owing to the low organic matter content of the soil. Tests of acid phosphate and rock phosphate may be carried out by those who are interested, to determine which material will be the more profitable for use under their particular conditions. Where truck crops are grown, the application of a complete commercial fertilizer would certainly be very desirable on this soil. Large increases in the yields of various truck crops are secured when certain complete commercial fertilizers are applied. The type is well suited to the growing of melons, potatoes, and all kinds of garden truck, and with the proper incorporation of organic matter and the use of the right kind of complete commercial fertilizers, very profitable yields of these crops may be secured.

CLYDE SILTY CLAY LOAM (85)

The Clyde silty clay loam is a minor soil type, covering 0.9 percent of the total area. It occurs in a considerable number of small areas scattered thruout the uplands in various parts of the county. The most extensive area of the type is found in the central part just west of Floyd Crosing. Another area which is considerable in size is found northwest of Powersville. Many smaller areas of the type are found in depressions or flat areas near the heads of streams and broad flat stream channels where drainage is poor or lacking.

The surface soil of the Clyde silty clay loam is a very dark brown to black silty clay loam 10 to 16 inches in depth. The subsoil is a gray clay or silty clay loam, mottled with dark gray and iron stains. In the more poorly drained areas the surface soil in the upper two or three inches is apt to be mucky. The subsoil is generally more mottled. Large amounts of organic matter are found in the surface soil and in the upper subsoil.

In topography the Clyde silty clay loam is nearly level to flat or depressed. The drainage is poor, owing to this topographic position and to the heavy character of the soil and subsoil. In areas which have not been ditched or tiled, water stands on the surface of the land for some time after every rain.

Most of the type is in native grasses which are either cut for hay or pastured.

The yields of hay range from one to two and one-half tons per acre. When well drained, general farm crops may be grown on the soil. Satisfactory yields are usually secured. Small grains, however, are likely to lodge badly on the soil.

The chief need of the Clyde silty clay loam to make it more productive is for the installation of tile to carry away the excessive moisture. When well drained, either by the installation of tile or the use of ditches, general farm crops may be grown very satisfactorily. Small amounts of farm manure may be used with profit on this soil when it is newly drained in order to stimulate the production of available plant food. Large amounts should not be added and the manure should not be applied preceding the growing of a small grain crop, as it is likely to cause the grain to lodge. The type is acid in reaction and lime should be applied if legumes are to be grown. The application of a phosphate fertilizer would certainly be very desirable on this soil. Experiments have indicated that acid phosphate or rock phosphate may give large crop increases. Whether acid phosphate or rock phosphate should be employed cannot now be definitely stated. Tests of the two phosphates under individual farm conditions are recommended.

DICKINSON LOAM (174)

The Dickinson loam is a minor soil type, covering 0.4 percent of the total area. It is found in a number of small areas in various parts, chiefly in the south central townships and in the northeastern part of the county. There is no large development of the type nor are there any large individual areas of the soil. The most extensive areas are found in the southwestern part in Scott Township.

The surface soil of the Dickinson loam is a dark brown to very dark brown loam, 9 to 12 inches in depth. The surface soil varies from a coarse sandy loam to a silt loam in many areas. The subsoil is a lighter brown or yellowish-brown loam, extending to a depth of 18 to 20 inches. The subsoil below that point is a yellowish gravelly sandy clay to gravelly sandy loam. In some places the lower part of the three foot section is a mass of sticky sand and gravel. In the southwestern part of the county small areas of the silt loam have been included with the type owing to their small extent. The surface soil in these areas consists of a dark brown to very dark brown silt loam, containing considerable fine sand. It is usually deeper than the typical Dickinson loam, ranging from 12 to 18 inches in depth.

In topography the Dickinson loam is undulating to rolling. It usually occurs on low knolls in the Carrington silt loam upland areas. The drainage of the type is adequate to excessive, owing to the porous nature of the subsoil.

Corn, oats and hay are the chief crops grown on this soil. The yields are somewhat lower than those obtained on the adjoining Carrington soils and large increases in crop yields may be secured thru proper soil treatments. The type is low in organic matter and liberal amounts of farm manure should be applied. When farm manure is not available, leguminous crops should be turned under as green manures in order to build up the content of organic matter in the soil, make it more productive, and insure more satisfactory crops in seasons of dry weather. The type is acid in reaction and lime should be employed for the best growth of legumes. Increases in the yields of general farm crops will also

follow the application of lime to this type. The use of a phosphate fertilizer is strongly recommended. Acid phosphate will probably be more desirable for use at the present time owing to the low content of organic matter in the soil. However, tests of rock phosphate and acid phosphate may be carried out by individual farmers on this soil to determine which will be the more satisfactory for general use. Complete commercial fertilizers are probably less desirable to employ on this type than acid phosphate as the latter will probably give quite as large crop increases at a lesser expense.

ROSEVILLE SILT LOAM (205)

The Roseville silt loam is a very minor soil type, covering only 0.1 percent of the total area. Only two areas of the type are developed, the largest containing approximately 400 acres and found just east of the village of Roseville. The smaller is a mile north of Marble Rock.

The surface soil of the Roseville silt loam is a gray to grayish-brown silt loam, 6 to 10 inches in depth. The upper subsoil is a pale yellowish to yellowish-brown silty clay loam, extending to a depth of 22 to 26 inches. Below that point the subsoil is a gray, heavy, plastic, coarse sandy clay mottled with rusty brown, orange and red. In the area a mile north of Marble Rock, there is a variation from the typical soil. Here the surface soil is a brown to very dark brown mellow silt loam 12 to 14 inches in depth, underlaid by a yellowish to grayish-brown heavy silt loam, grading at 20 to 30 inches into a brownish-red plastic silty clay, slightly mottled with yellow and gray.

In topography the Roseville silt loam varies from gently undulating to sloping. The drainage of the type is generally adequate. There are some parts of the areas, however, where drainage is not as satisfactory as it should be.

Practically all the type is in cultivation or pasture. Corn is the chief crop grown and next in importance are oats and hay. In some areas wheat, barley and rye are grown. The yields of corn amount to 35 to 55 bushels per acre, oats 28 to 60 bushels and hay one to two tons.

In some areas of this type, drainage is desirable and the installation of tile is the first treatment needed for satisfactory crop yields. The soil is low in organic matter and applications of farm manure are very desirable. Liberal amounts of this material should be employed. Leguminous crops turned under as green manures would be of value on this soil. The application of lime is necesary in order to remedy acidity if legumes are to be grown. The application of a phosphate fertilizer would be of considerable value on this soil and tests of rock phosphate and acid phosphate are recommended.

LOESS SOILS

There is one loess soil type in the county, the Clinton silt loam. It is minor in extent, covering only 0.3 percent of the total area.

CLINTON SILT LOAM (80)

The Clinton silt loam occurs in only one area, along the Cedar River in Floyd Township, just north of the town of Floyd.

The surface soil of the Clinton silt loam is a gray to light grayish-brown mel-

low silt loam, 10 to 14 inches in depth. The upper subsoil is a dark grayish-brown heavy silt loam to silty clay loam. The lower subsoil at 22 to 26 inches is a pale yellowish to grayish-yellow silty clay loam mottled with yellow and gray. In the forested areas of the type the upper inch or two of the soil is a dark brownish-gray in color.

In topography the Clinton silt loam varies from gently rolling to rolling or rough. It occurs on the tops of the higher hills. Drainage is well established. The soil is subject to erosion and considerable washing frequently occurs.

About 70 percent of the type is in cultivation. The forested area supports a growth chiefly of maple, ash and elm. Some windbreaks of evergreens and maples occur on the type. The cultivated portion of the soil is used for the production of corn, oats and hay. The yields of these general farm crops are somewhat lower than those secured on the Carrington silt loam. The type is particularly in need of organic matter and liberal applications of farm manure should be made. The turning under of leguminous crops as green manures would also be of material aid in building up the supply of organic matter. The use of leguminous green manures would also add to the nitrogen content of the soil, which is not high. The soil will respond to applications of a phosphorus fertilizer, and tests of acid phosphate are recommended. Farmers who are interested may compare the relative value of rock phosphate and acid phosphate. It would seem, however, that at the present time, acid phosphate will probably be more desirable for use owing to the low organic matter content of the soil. The type is acid in reaction and applications of lime should be made if legumes are to be grown. The use of lime will, however, bring about increases in the yields of general farm crops as well as in the yields of legumes.

TERRACE SOILS

There are nine terrace soils in the county, classified in the O'Neill, Waukesha, Bremer, Buckner and Millsdale series. Together they cover 11.9 percent of the total area of the county.

O'NEILL LOAM (108)

The O'Neill loam is the largest individual terrace soil, and the fifth most extensively developed soil type. It covers 4.1 percent of the total area. It is found on the high terraces along the major streams of the county, occurring in numerous areas, many of which are quite extensive in size. Large developments of the type are found along the Cedar River, particularly in the vicinity of Charles City and north along the river. Large areas of the type are also found along the Shellrock River, particularly in the vicinity of Rockford and north from that city and in numerous areas south of the city along the Shellrock River. Many other smaller areas of the type are found along the streams, and tributary streams in various parts of the county.

The surface soil of the O'Neill loam is a dark brown, light textured loam, 10 to 12 inches in depth. The upper subsoil is a brown to yellowish-brown sandy loam to a depth of 20 to 24 inches. The lower subsoil is a brownish-yellow fine to medium sand containing much gravel. Included with the type there are a

few small areas of the fine sandy loam and silt loam of the same series, which are too small to be shown separately on the map.

The type occurs on the terraces 10 to 15 feet above the normal level of the rivers and larger creeks and from 8 to 10 feet above the smaller streams. Three miles south of Rockford, however, it occurs on the terraces which are only 2 to 4 feet above the first bottoms. The type is above overflow and drainage is excessive.

All of the O'Neill loam is in cultivation or pasture. The only tree growth consists of wind breaks which have been planted north and west of the dwellings and of a few willows along old fence rows. Corn is grown most extensively on the type, some oats and hay also being produced. Wheat, barley, rye, millet and sorghum are grown to some extent. Potatoes are produced on most farms on this type.

The yields of general farm crops on the O'Neill loam are somewhat below those secured on the upland soils. Corn produces from 25 to 40 bushels per acre and oats from 28 to 45 bushels per acre in favorable seasons. In dry seasons, however, the yields are very low as the crops are injured by drouth.

The O'Neill loam is particularly in need of organic matter if it is to be made more productive. Liberal applications of farm manure should be made to this type and the turning under of leguminous crops as green manures would be of value. The building up of the supply of organic matter in this soil will put it in a better condition to resist the unfavorable effects of dry weather. The type is acid in reaction and applications of lime should be made for the best growth of legumes. Increases in the yields of general farm crops will also follow the addition of lime. The application of a phosphate fertilizer is very desirable on this soil and tests of rock phosphate and acid phosphate are recommended. Experiments have indicated the value of applications of manure, lime and phosphorus. The need of phosphorus on the type may be determined by tests, using acid phosphate on small areas. When a need of phosphorus is shown, tests may be carried out comparing rock phosphate and acid phosphate. In this way farmers may learn which material will be the more profitable for general use. Complete commercial fertilizers will probably be less desirable on this type than acid phosphate. However, tests may be carried out on small areas comparing the two materials, to determine whether or not the complete fertilizer will be desirable for general use. When potatoes or other truck crops are grown, the application of certain complete commercial fertilizers may frequently be very profitable.

O'NEILL SILT LOAM (206)

The O'Neill silt loam is the second largest terrace type, covering 2.9 percent of the total area. It occurs in numerous areas along the various rivers and tributary streams in the county, the largest development of the type being found along Flood Creek, from the Butler County line north to the vicinity of Roseville. The type is also rather extensively developed along the Little Cedar River. Smaller areas occur along the Cedar River and the Shellrock River and many of the tributary streams.

The surface soil of the O'Neill silt loam is a dark brown silt loam, 8 to 12

inches in depth. The subsoil is a lighter brown silt loam to a depth of 15 to 24 inches, at which point it becomes a yellowish-brown sandy clay to sticky clayey sand, containing much coarse sand and gravel. Below the three foot section, the substratum consists of sticky sand and gravel.

There are some variations from the typical soil in the various areas. In some places along Flood Creek in the vicinity of Roseville, in Sections 9, 15, 22, 23, 26, 35 and 36 of Ulster Township and Section 1 of Union Township, the surface soil is much lighter in color. Two other areas which are similarly light in color are found along the north side of the Cedar River in Section 1 of Riverton Township.

The O'Neill silt loam occurs on the high terraces, usually 6 to 15 feet above the normal stream level. The topography varies from level to very gently sloping. Drainage is excessive and in dry seasons crops are apt to suffer from drouth. The soil is well above overflow.

About 85 percent of the type is in cultivation, the rest being utilized for pasture. Corn and oats are the chief crops grown. Some millet and sorghum are produced. The yields of general farm crops on this type are very much the same as those secured on the O'Neill loam. Methods of treatment for increasing the crop yields are similar to those recommended for the O'Neill loam. Liberal applications of farm manure should be applied and the turning under of leguminous crops as green manures is very desirable in order to increase the organic matter content in this soil and provide for the securing of better crops in dry seasons. The type is acid in reaction and will respond to the application of lime, particularly if legumes are to be grown. The use of a phosphate fertilizer is very desirable and tests of acid phosphate are urged. Farmers who are interested may compare the relative value of rock phosphate and acid phosphate by simple tests carried out under their own conditions. Complete commercial fertilizers will probably be less desirable than acid phosphate. Extensive applications of complete brands should not be made until tests are carried out in comparison with acid phosphate.

WAUKESHA SILT LOAM (75)

The Waukesha silt loam is the third largest terrace type, covering 2.1 percent of the total area. It is found mainly on the terraces along the Shellrock River. The most extensive areas occur in the vicinity of Rockford and Marble Rock. Smaller scattered areas are found along the Cedar and Little Cedar Rivers and along many of the smaller streams in the county.

The surface soil of the Waukesha silt loam is a dark brown to very dark brown mellow silt loam, 16 to 18 inches in depth. The subsoil is a yellowish-brown heavy silt loam to silty clay loam.

Some variations from the typical soil occur in the different areas. In Section 31 in Scott Township the surface soil is a dark brown to black mellow silt loam, underlaid at 18 to 20 inches by a yellowish-brown silty clay loam, faintly mottled with gray in the lower depths. Areas similar to this occur along the Mitchell County line north of Devonia. North of Rockford in Section 3 of Rockford Township, south of Marble Rock in the southeastern part of Section 21 in Union Township and in Section 33 of Riverton Township, there are small areas

in which the surface soil approaches a loam in texture. All of these areas are small and are included with the silt loam because of their limited extent.

The Waukesha silt loam is found on the terraces above overflow. Along the smaller streams it is four to six feet above the normal water level, and along the Shellrock, Cedar and Little Cedar Rivers, from 12 to 20 feet above the water level. In topography the type varies from level to very gently sloping. Drainage conditions are entirely satisfactory.

About 90 percent of the Waukesha silt loam is in cultivation or utilized for pasture. The tree growth consists of a few willows along old fence rows and windbreaks which have been set out around the farmsteads. The chief crops grown are corn, oats and hay. Some wheat, rye and barley are also produced. Corn yields from 35 to 50 bushels per acre, oats from 30 to 35 bushels and hay from 1 to 2 tons per acre. The type will respond to applications of farm manure and liberal amounts of this material should be used. The turning under of leguminous crops as green manures would also be of value on this soil. It is acid in reaction and the application of lime is very desirable if the best growth of legumes is to be secured. An increase in the growth of general farm crops will also follow the addition of lime to this soil. The application of a phosphate fertilizer is very desirable and tests of rock phosphate and acid phosphate on the soil are recommended.

BREMER SILT LOAM (88)

The Bremer silt loam is the fourth largest terrace type, covering 0.9 percent of the total area. It is found on the terraces along the Cedar, Shellrock and Little Cedar Rivers and along Flood, Beaver, and Beemis Creeks and Ackley Run. There are numerous small areas of the type along these various streams, none being very extensive. The largest development is along Beemis Creek in Scott Township.

The surface soil of the Bremer silt loam is a dark brown to very dark brown friable silt loam to a depth of 16 to 18 inches. The soil contains considerable very fine sand. The subsoil is a dark grayish-brown to black silty clay mottled with rusty brown.

Some variations from the typical soil occur. In some places the upper subsoil is a dark brown to grayish-brown heavy silt loam to silty clay loam, grading into a black silty clay at 24 to 28 inches. Along Beaver Creek, Beemis Creek and Ackley Run, the surface soil is a very dark brown to black mellow silt loam, 16 to 18 inches in depth. Here, the upper 2 to 3 inches of the uncultivated areas of the type are somewhat mucky. The upper subsoil is a brown to slightly yellowish-brown or grayish-brown heavy silt loam to 24 to 30 inches. The lower subsoil is a yellowish-brown to grayish-brown silty clay loam, slightly mottled with yellow. In depressions thruout such areas, the lower three or four inches of the soil section is a gritty, silty clay, mottled with yellow and yellowish-brown. Smaller areas similar in character to these just described occur along Flood Creek, in the western part of Section 7 of Pleasant Grove Township. In Section 19 of Cedar Township along the Mitchell County line, the soil resembles the Clyde silt loam. Small areas along the Cedar River might have been separated out as a loam, had they been of sufficient size. A few areas of the silty clay loam too small to show on the map are also included.

The Bremer silt loam lies on the terraces from 2 to 6 feet above the first bottoms. The topography is level to gently sloping. Drainage is fair. In many cases tiling is very necessary if general farm crops are to be most successfully grown. About 50 percent of the soil is in cultivation. Corn and oats are the chief crops grown. Corn yields 35 to 70 bushels per acre and oats 40 to 60 bushels. Oats have a tendency to lodge. Considerable acreage of the type is left in wild grasses which are cut for hay.

The first treatment needed for securing the most satisfactory crop yields on this soil is the installation of tile and adequate drainage of the type. Small applications of farm manure would be of value on newly drained areas to stimulate the production of available plant food. Large amounts should not be applied, however, and the manure should not be added preceding the growing of a small grain crop as it tends to cause the grain crop to lodge. The type is acid in reaction and the application of lime will be of value where legumes are to be grown. The use of a phosphate fertilizer would be valuable on this type and tests of acid phosphate and rock phosphate are recommended.

O'NEILL SANDY LOAM (126)

The O'Neill sandy loam is a minor soil type, covering only 0.8 percent of the total area. It is found in a number of small areas along the Cedar and Shellrock Rivers. The largest developments of the type are along the latter river south of Rockford and along the Cedar River in the vicinity of Charles City.

The surface soil of the O'Neill sandy loam is a dark brown sandy loam 12 to 14 inches in depth. The subsoil is a yellowish-brown to brownish-yellow sand to coarse sand. Considerable gravel is found in the lower part of the three foot section.

The type is found on the terraces 10 to 18 feet above the normal level of the stream in most of the areas. In one area two and one-half miles south of Rockford, the type is on the terrace 8 feet above the stream level. In topography the soil is level, the drainage is excessive and crops suffer from drought in dry seasons.

Practically all of the soil is in cultivation. General farm crops are grown and in some areas such truck crops as watermelons, cantaloupes and potatoes are produced. Yields on this soil type are very much the same as those on the O'Neill silt loam, being slightly lower in unfavorable seasons. The soil will respond to applications of farm manure and liberal amounts of this material should be applied. The turning under of leguminous crops as green manures would be very desirable in order to build up the content of organic matter in the soil. By the use of farm manure and leguminous green manures, there will be less danger of injury to crops in dry seasons. The type is acid and should be limed for the growth of legumes. The application of a phosphate fertilizer is very desirable on this soil when general farm crops are to be grown. Acid phosphate is recommended for use in preference to rock phosphate because of the low supply of organic matter. Farmers are urged to test the value of acid phosphate on this soil. Where truck crops are grown the application of a complete commercial fertilizer would undoubtedly be of value and the use of a complete fertilizer, particularly made up for the crop to be grown, is recommended.

BUCKNER LOAM (38)

The Buckner loam is a minor terrace type, covering 0.7 percent of the total area. It occurs in a number of small areas along the Little Cedar and Shellrock Rivers. The largest development of the type is along the Cedar River, north of Rockford and along the Shellrock River, north of Charles City and south of Rockford.

The surface soil of the Buckner loam is a dark brown to black friable loam 20 to 22 inches in depth. The subsoil is a slightly lighter brown heavy silt loam, containing considerable amounts of fine sand. The soil varies from the typical in Section 36 of Rockford Township. Here the surface soil is a dark brown loam extending to a depth of 30 to 34 inches, at that point resting upon the limestone bedrock. Small fragments of the limestone occur imbedded in the soil and subsoil. Included with the type, there are small areas of the silt loam texture which were too small to show on the map.

The type occurs on the terraces 4 to 6 feet above the normal level of the stream. In topography it is level, and drainage in normal seasons is adequate.

Practically all of the Buckner loam is utilized for corn or pasture. Corn yields from 35 to 50 bushels per acre. Grasses grow well and good pasture is available on the type. The soil will respond to farm manure and liberal amounts of this material should be applied. The turning under of leguminous crops as green manures would be very desirable in many cases. The type is acid in reaction and additions of lime are recommended, especially if legumes are to be grown. The use of a phosphate fertilizer is desirable on this soil and tests of acid phosphate and rock phosphate are recommended.

BUCKNER FINE SANDY LOAM (45)

The Buckner fine sandy loam is a minor soil type, covering only 0.2 percent of the total area. It is found on the terraces along the Cedar River where it occurs in small areas in the bends of the river, south of Floyd and in the vicinity of Charles City.

The surface soil of the Buckner fine sandy loam is a dark brown to very dark brown mellow fine sandy loam, extending to a depth of three feet or more. There is very little change in the soil material even in the lower part of the soil section. There, however, it is apt to be slightly heavier in texture. Included with the type there are small areas of fine sand which were too small to show separately on the map. In topography the type is level to very gently undulating. Drainage is good to excessive.

The soil is used almost exclusively for the production of corn. Yields are about the same as those on the Buckner loam, being slightly lower in unfavorable seasons. A few areas which are not cultivated are utilized for pasture, and excellent stands of pasture grasses are maintained.

This type will respond to applications of farm manure, the turning under of leguminous crops as green manures, and large increases in the yields of general farm crops may be secured thru the use of these materials. It is slightly acid in

reaction and lime should be applied if legumes are to be grown. The application of a phosphate fertilizer is very desirable and tests of acid phosphate and rock phosphate are recommended.

MILLSDALE LOAM (188)

The Millsdale loam is a very minor type in the county, covering only 0.1 percent of the total area. It is found only on the terraces along the Shellrock River and along some of the tributary streams. It occurs in a number of small areas.

The surface soil of the Millsdale loam is a dark brown fine textured loam, 8 to 12 inches in depth. The subsoil is a brown to slightly yellowish-brown loam to fine sandy loam, extending to a depth of 18 to 24 inches. Here the soil rests upon limestone rock. In some cases the limestone is found nearer to the surface and the dark colored soil extends down to the lime rock. South of the Shellrock River in Sections 35 and 36 of Rockford Township, the surface soil is almost a fine sandy loam in texture. Here the limestone occurs within 8 to 15 inches of the surface.

The soil occurs on the terraces 4 to 6 feet above the normal level of the river in most areas. Occasionally it is somewhat higher, being 5 to 8 feet above the level of the low terraces. In topography the soil is level. Drainage is apt to be excessive and crops are apt to suffer in periods of drought.

Most of the type is not cultivated except where it occurs in spots in fields of some other soil type. Most of it is used for pasture land and grasses do very well. When cultivated this soil will respond to applications of farm manure and the addition of a phosphate fertilizer.

BUCKNER FINE SAND (46)

The Buckner fine sand is a minor type in the county, covering only 0.1 percent of the total area. It is found only on the terraces of the Cedar River. There are a number of small areas of the type occurring chiefly south of Charles City.

The surface soil of the Buckner fine sand is a dark brown to very dark brown fine sand to loamy fine sand, 16 to 20 inches in depth. The subsoil is a lighter brown to yellowish-brown fine sand.

The type occurs on the terraces occupying low narrow ridges, ranging in width from 20 to 100 feet. These ridges are slightly higher than the adjacent Buckner loam. The drainage of the type is excessive and crops suffer from drought.

Practically none of the soil is under cultivation at present. When cultivated it should receive liberal applications of farm manure or leguminous green manure crops should be turned under. It is acid in reaction and lime should be applied for the best growth of legumes. The use of a phosphate fertilizer would undoubtedly be of value on this type and tests of acid phosphate would be very desirable.

SWAMP AND BOTTOMLAND SOILS

There are three swamp and bottomland soils in the county, classified in the Wabash and Lamoure series, and these with the areas of meadow, peat and muck

make a total of five soil areas. Together they cover 4.1 percent of the total area of the county.

WABASH SILT LOAM (26)

The Wabash silt loam is the largest bottomland soil, covering 2.6 percent of the total area. It is developed on the bottomlands along all the rivers and tributary streams.

It occurs on the bottomlands along all of the rivers and most of the smaller streams of the county. There are no large areas of the type, as it is found mostly in narrow strips along the various streams.

The surface soil of the Wabash silt loam is a dark brown to black silt loam, 10 to 15 inches in depth. The subsoil is a grayish-brown to black silty clay loam to silty clay, mottled with dark gray in the lower part of the three-foot section. There are some variations in the soil, and in some places the texture of the surface soil is somewhat variable. In other areas the color is somewhat different from the typical. The type is subject to overflow and drainage is poor.

Practically all of the soil is utilized for pasture purposes. Only a very small portion is under cultivation. The first treatment needed if the soil is to be cultivated is protection from overflow. Straightening the streams and dredging the channels would help materially. The installation of tile would be very desirable. When protected from overflow and thoroly drained, satisfactory yields of general farm crops may be secured. The application of small amounts of manure would be very valuable on this type when the soil is newly drained. It is acid in reaction and the application of lime would be of value when legumes are to be grown. The use of a phosphate fertilizer would undoubtedly prove profitable and tests of acid phosphate and rock phosphate are recommended.

WABASH LOAM (49)

The Wabash loam is the second largest bottomland soil, covering 1.0 percent of the total area. It is developed in the bottomlands along all of the rivers and tributary streams. In practically all cases it is found in narrow strips along the streams, except in Sections 17 and 18 of Pleasant Grove Township, where considerable areas of the type have been developed along Flood Creek.

The surface soil of the Wabash loam is a very dark brown to black mellow loam, 15 to 18 inches in depth. The subsoil is a dark grayish-brown to black friable silty clay loam. There are many variations from the typical soil. In some areas the surface soil ranges from a grayish fine sandy loam to a black sandy loam, mottled with dark gray in the subsoil, while the surface soil varies from a fine textured loam thru a fine sandy loam to a sandy loam. The type occurs on the bottoms, slightly above the normal water level of the streams and it is subject to overflow.

Very few areas of the Wabash loam are cultivated, the larger portion being utilized for pasture purposes. On the cultivated areas corn is grown chiefly. Yields range from 35 to 70 bushels per acre in favorable seasons. The wild grasses grown on some of the areas yield from one to two and a half tons of hay per acre.

The chief need of this soil if it is to be cultivated is adequate drainage and

protection from overflow. The straightening and dredging of the streams and the installation of tile are very necessary to bring about the proper moisture conditions in the soil. The application of a small amount of farm manure would be of value when the type is newly drained. Liberal amounts should not be applied, however, preceding the growing of a small grain crop as it may cause the crop to lodge. The application of lime will improve conditions for the growth of legumes as the type is acid. The application of a phosphate fertilizer would undoubtedly be of value and tests of rock phosphate and acid phosphate are recommended.

MEADOW (20)

There is a small area of meadow in the county, covering 0.3 percent of the total area. It is found only on the bottoms of the Little Cedar and Cedar Rivers in small areas.

Meadow consists of first bottom soils that are so variable in color and texture that the separation into types is impossible. The surface texture ranges from sand to clay loam and there are many hummocky areas. It is found two to four feet above the normal level of the streams and is frequently under water and subject to constant change in characteristics. Most of the meadow is forested with a few scattered elms. There are some ash, hickory and maples. Grass grows rather poorly. The entire area in meadow is utilized for pasture purposes.

PEAT AND MUCK (21)

There is a small acreage of peat and muck, totaling 0.1 percent of the area. There are a number of areas in various parts of the county, most of them quite small in extent. The larger areas are found in the northern part in Sections 21 and 26 of Floyd Township.

Peat consists of a brown to very dark brown or black finely fibrous mass of partly decomposed plant remains, containing some mineral matter. It extends to a depth of 6 to 20 inches where it rests upon a bed of black, grayish-black or gray material ranging in texture from a fine sand to a silty clay. In some of the areas decomposition of the plant remains has progressed so far that the structure of the plants has disappeared. Here the color is darker. The soil in such areas is called muck. In most places the peat and muck are so closely associated that they could not be separated.

These areas are level to flat in topography and drainage is poor. Most of the areas have not been reclaimed and are utilized only for pasture. The treatment needed for their reclamation includes first of all thoro drainage. When this is accomplished, deep fall plowing is valuable in order to hasten the decomposition of the plant remains and bring the material into better condition for the growth of general farm crops. It is preferable to seed the areas to timothy and alsike clover and utilize them for pasture for some years, thus allowing time for further decomposition of the plant remains. The growing of corn and small grains is unsatisfactory on newly reclaimed areas of peat. The growth of onions, potatoes, tomatoes and other truck crops may prove very satisfactory. If such crops are grown it may frequently be desirable to apply certain commercial fertilizers. Very excellent results are frequently secured from the application of acid phosphate and muriate of potash to these areas.

LAMOURE SILTY CLAY LOAM (111)

The Lamoure silty clay loam is a very minor soil type, covering only 0.1 percent of the total area. It is found only on the bottoms along Beaver Creek, a rather considerable area being mapped along this creek in Rockford Township.

The surface soil of the Lamoure silty clay loam is a very dark brown to black silty clay loam to heavy silt loam extending to a depth of 12 to 16 inches. The subsoil is a dark gray to very dark grayish-brown silty clay to clay mottled with rusty brown. Both soil and subsoil are highly calcareous, lime occurring in considerable amounts thruout the soil section. In one or two areas the surface soil very closely resembles a muck.

The type occurs on the bottomlands one to three feet below the level of the adjacent terrace soils and from two to four feet above the streams. Drainage is poor.

A small portion of the area of the type is in cultivation, the remainder being utilized for pasture or for the production of wild hay. Corn is grown on the cultivated areas. For the best yields of farm crops on this type, the first treatment needed is thoro drainage. When this is accomplished, very satisfactory yields may be secured. The application of a phosphate fertilizer would probably be desirable and tests of acid phosphate and rock phosphate are recommended.

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 coöperation 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.

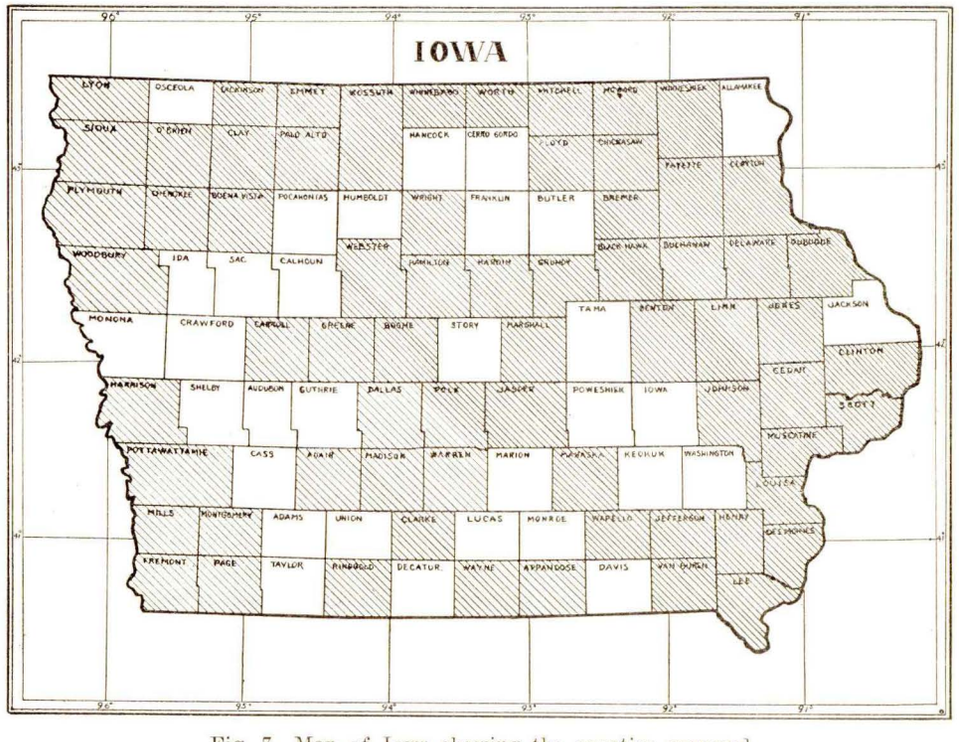

Fig. 7. Map of Iowa showing the counties surveyed.

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.

THE "SOIL DERIVED" ELEMENTS

Phosphorus, potassium, calcium and surfur, known as "soil derived" elements, may frequently be lacking in soils, and then a fertilizing method 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 surfur 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, surfur fertilizers may come to be considered of much value.

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 solution 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 rapidly 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.

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 surfur 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 element 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

TABLE I. PLANT FOOD IN CROPS AND VALUE
Calculating Nitrogen (N) at 16c (Sodium Nitrate ($NaNO_3$)), Phosphorus (P) at 12c (Acid Phosphate), and Potassium (K) at 6c (Potassium Chloride (KCl)).

Crop	Yield	Plant Food, Lbs.			Value of Plant Food			Total Value of Plant Food
		Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium	
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
Oats, 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

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 lease 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 contain 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.

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 crop 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 plan 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 thoro 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.

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 of 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.

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 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 nitrigen 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.

By using all the crop residues, all the manure produced on the farm, and giving well-inocu-

lated 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 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 result sof 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 exception 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, particularly 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 areas 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. 8.

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 the 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 is very close to the surface. The fertility of these soils and their needs are greatly influenced, therefore, by their depth.

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 division may then be made into various drift and loess sails 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 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 CHARACTERISTICS

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

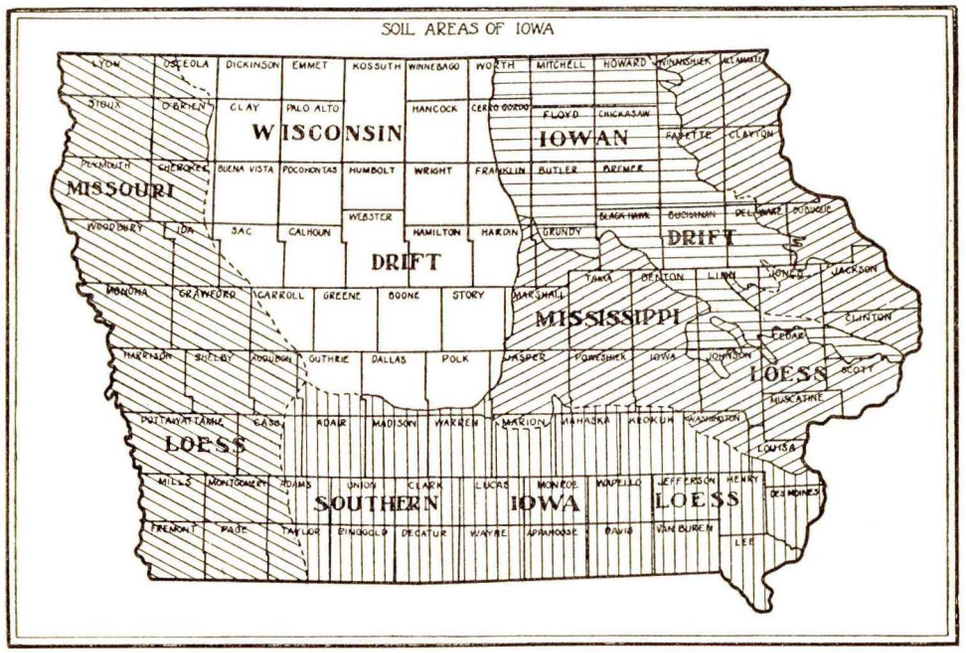

Fig. 8. Map showing principal soil areas in Iowa.

type boundaries. In some cases, however, there is a graduation 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, colluvial 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—2.0 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 percent clay, usually mixed with much silt; always more than 50 percent silt and clay.

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 percent 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 percent.

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 percent 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.

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*25mm equals 1 in. †Bureau of Soils Book.

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 map of the county.